Swedish University of Agricultural Sciences
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An assessment of public procurement of timber buildings – a multi-level perspective of change dynamics within the Swedish construction sector

En analys av offentliga aktörer och flervåningshus i trä – ett socio-tekniskt perspektiv på djupgående strukturella förändringar inom den svenska byggsektorn

Erik Ingmar

Master Thesis
No 152

ISSN 1654-1367
Uppsala 2015

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Master Thesis, 30 ECTS credit *Advanced level in Business Administration*
MSc in Forestry 09/14 *(EX0753)*

Supervisor SLU, Department of Forest Products: Denise McCluskey
Examiner SLU, Department of Forest Products: Anders Roos

Sammanfattning

Drift och konstruktion av byggnader inom EU belastar klimatet med hälften av EU:s utvunna material samt en tredjedel av unionens växthusgasutsläpp. Under det senaste decenniet har byggsektorn besvarat denna oro genom att fokusera på energieffektivitet och reduktion av utsläpp i driftsfasen. Ny forskning indikerar dock att klimatpåverkan från själva byggprocessen är betydligt större än man tidigare bedömt, vilket har skiftat fokus till att inkludera hållbara materialval och byggprocesser. Trots starka miljörelaterade drivkrafter, har ett sådant skifte mot hållbara och innovativa byggsystem haft en långsam utveckling inom Sverige.

För att hantera miljökraven och en låg innovationsgrad krävs djupgående strukturella förändringar inom byggsektorn. För att tydliggöra dynamiken i dessa djupgående strukturella förändringar analyserar detta examensarbete den svenska byggsektorn genom en heuristisk socio-teknisk teori – The Multi-level Perspective (MLP). Denna teori behandlar förändring i en sektor utifrån multipla dimensioner, vilket skiljer sig från traditionella studier som fokuserar på enskilda dimensioner som beteende eller teknologi. Teorin innefattar betydelsefulla delar i djupgående förändringar, inklusive policy, industristruktur, marknader, forskning och kulturella dimensioner.

I enighet med teoretiska ramverket, den innovation som är i fokus är flervåningshus i trä: vilket anses som en innovativ byggmetod med miljömässiga fördelar. Dessutom är offentliga byggnadsaktörer i fokus i denna studie eftersom de förväntas vara viktiga i en förändring mot minskade klimatutsläpp och ökad innovation inom sektorn. Kunskaperna är begränsade om offentliga bostadsaktörers roll i denna förändring. Examensarbetet syftar till att introducera MLP som ett analytiskt verktyg för att analysera förändring inom den svenska byggsektorn, med fokus på flervåningshus i trä och offentliga aktörer.

Metodiken hämtar inspiration från flermetodsforskningen, där en litteraturstudie av forskning kring flervåningshus i trä har utförts och kombinerats med semi-strukturerade intervjuer. Litteraturstudien berör den nationella byggsektorn med fokus på flervåningshus i trä. För de tre fallen Växjö, Skellefteå och Falun har sekundär- och primär data från intervjuer använts.

Sektorn illustreras och analyseras med fokus på flerbostadshus i trä, med det övergripande målet att undersöka hur byggandet av flerbostadshus i trä kan öka. Genom MLP illustreras interaktioner mellan makrofaktorer och den dominerade byggtekniken (platsbyggda flervåningshus i betong), samt hur detta relaterar till den nisch som träbyggandet idag utgör. Därtill har undersöks tre fall där offentliga aktörer agerat för att utveckla byggandet av flervåningshus i trä på en lokal nivå.

Fallstudierna visar att de offentliga aktörerna har utvecklat det lokala träbyggandet genom att artikulera visioner och förväntningar, vilket attraherar investerare och guidar träbyggnadsaktörer. Träbyggnadsstrategier och funktionella krav i den offentliga upphandlingen är exempel på detta. Offentliga aktörer utvecklar också nätverk som exempelvis involverar den lokala byggindustrin, universitet och kommunala aktörer. De studerade kommunerna medverkar även aktivt i formella externa nätverk som Trästad och Nordic Wooden Cities. De studerade fallen att värdefulla erfarenheter i de olika dimensionerna erhållits. Erfarenheter som illustreras är bland annat utveckling av lokala SME och ökad konkurrens, innovativ upphandling och organisatoriska förändringar i de kommunala organisationerna.

Slutligen visar studien att MLP är ett användbart analytiskt verktyg för att undersöka djupgående förändringar inom den svenska byggsektorn. Resultaten illustrerar och analyserar barriärer, drivkrafter och möjliga vägar mot en djupgående förändring från dominerade praktiker till ett ökat hållbart träbyggande av flervåningshus.

Nyckelord: *Multi-level perspective; Socio-technical transitions; multi-storey housing, timber building, industrial building, sustainability transitions*

Abstract

The construction and use of buildings in the EU accounts for half of the EU's extracted materials and energy consumptions, and a third of greenhouse gas emissions. In the past decade, the construction sector has responded to such concerns by focusing on post production energy efficiency. However, new findings indicate that upstream construction processes influence emissions significantly – necessitating a shift in focus to include material choices and building processes. Nonetheless, despite environmental concerns, such a shift to more sustainable and innovative building methods has been slow to get underway within Sweden.

To address environmental demands and low innovation rate, the construction sector requires deep structural change. To understand the dynamics of these deep structural changes, this thesis assesses the Swedish construction sector using a novel heuristic socio-technical theory, the multi-level perspective (MLP). This theory assesses a sector from multiple dimensions and moves beyond technological fixes or behavior changes, incorporating the key elements of change including policy, industry structure, markets, culture and science.

Within an MLP framework, the focal innovation is timber based multi-story timber building approaches: in Sweden, such multi-storey timber building methods can be considered an innovative and sustainable construction technique. Moreover, publically owned facility management organizations were the focal actors and procurement actors are expected to play a key role in the transition towards the reduction of GHG. Accordingly, this thesis uses a socio-technical framework, investigating a transition from onsite concrete building methods to timber based building. That is, this thesis introduces MLP analytical framework to assess change in the Swedish construction section with focus on timber building.

The study draws on multiple methods and a case study framework. Secondary data was used to assess the national construction sector and a mix of semi-structured interviews and secondary data for studying three cases; the municipalities of Växjö, Skellefteå and Falun.

The overall aim was to assess how timber based building can become more mainstream. Using MLP, national multi-level interactions between macro changes and the mainstream practices have been illustrated and assessed. Moreover, three local timber building cases have been investigated in depth, illustrating how public actors developed timber building at the local scale.

In the studied cases, public actors have developed timber building markets by articulating visions and expectation in order to attract and guide niche producers of timber solutions. Examples of such articulation processes include formulation and implementing timber building strategies and articulation of functional needs in public procurement processes. Public actors within the studied cases also build social networks, involving local industry, research institutions, and public actors. Moreover, all three municipalities participate actively in formal national timber networks. The local cases also illustrate valuable lessons learned regarding on multiple dimensions such as technology, organization, market demand, policy, and infrastructure requirements. Examples of local lessons illustrated in this thesis are local SME developments and thereby increased competition, innovative public procurement practices, and organizational changes in the public administrations.

The study shows that MLP is a useful framework for investigating deep structural changes within the multi-storey construction sector. It highlights barriers, drivers and pathways of a deep structural transition towards more environmentally sustainable timber based building.

Keywords: *Multi-level perspective; Socio-technical transitions; multi-storey housing, timber building, industrial building, sustainability transitions*

Foreword

I'd like to thank my supervisor Denise McCluskey for tremendous support during this process. Denise is a remarkable person, bright scientist and constantly positive. She has guided me through the ups and downs during my research, and this thesis would not have been possible without her help.

I also would like to thank the respondents for participating in interviews and providing excellent information about the local timber building developments. I believe that the interviewed persons are contributing to a more sustainable society with their work regarding timber building developments, and they should not underestimate their importance for the local timber building developments.

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1 Introduction

1.1 Environmental driving forces

1.1.1 Low carbon economy in Europe

Climate change is today a widely recognized issue and international, national, and local measures are undertaken in order to hinder the global warming. Within the European Union, policy measures are directed towards transforming Europe into a low-carbon and energy efficient economy (European Commission, 2015). In this low-carbon economy, a short term goal is to reduce the carbon emissions below 20 % compared to 1990 levels. The deadline is set to 2020, and the European market is well underway in achieving this goal. However, in the long term there is a need to decrease the emissions far more than 20 % if global warming should stay within two degrees compared to pre-industrial measures. Thus in 2030 the carbon reduction goal is 40 %, and in 2050 a reduction of 80-95 percent is targeted (European Commission, 2015).

Consequently policy measures regarding climate are long term within Europe. In this transition towards a low carbon economy, critical measures involve fostering environmental-friendly innovations and low carbon technology (ibid). Moreover, these innovations need to be cost-effective for successful implementation (Trott, 2011).

The transition towards a low-carbon economy in Europe has important implications not only for energy use, but also for sustainable use of material resources in EU (European Commission, 2011a). One identified sector with large potential of reducing its environmental impact is the construction sector. Within this sector, existing policies are mainly linked to energy efficiency and needs to be complemented with incentives for resource efficiency, involving the complete life cycle of buildings (European Commission, 2011a). The construction and use of buildings in the EU account for half of the extracted materials and energy consumption (European Commission, 2014) and a third of greenhouse gas (GHG) emissions (European Commission, 2011a).

Accordingly, the construction sector has a large potential of reducing its environmental impact, both through the use of energy-efficient measures and through sustainable use of resources. The use of resources within the sector is largely determined by design decisions and choices of construction materials (European Commission, 2014)

1.1.2 Upstream vs downstream carbon emissions in the Swedish construction sector

Within Sweden, a recent report indicate that GHG emissions from building processes are in the same size as the emissions from all the cars in Sweden (Sveriges Byggindustrier & IVA, 2014). Moreover, and perhaps more noteworthy, is that the report has made a detailed study of a typical concrete residential house build with “passive house” techniques. The results indicate that GHG emissions from the construction process (upstream) are in the same size as downstream processes (post-construction use for 50 years), pointing out the need for further focus on climate work in the upstream construction process (ibid). EU also recognizes that policies during the last two decades have failed to steer the construction sector into innovating on its own (European Commission, 2011a). Accordingly there is a need for a transition from conventional concrete and steel building structures to more sustainable and innovative building methods (ibid p.19).

1.1.3 Timber as a sustainable material

The use of timber has environmental advantages. This is one of the most studied areas and the most important effect is substitution of unsustainable materials to sustainable materials (Nord & Brege, 2013). Recent findings indicate that wood has substantial advantages regarding CO2 emissions compared to concrete and steel products (Oliver, Nassar, Lippke, & McCarter, 2014). This is also the general position in EU when promoting wood through policy measures across various sectors in order to reach its climate goals (European Commission, 2011b).

In spite of powerful environmental concerns, the implementation of low carbon technology has been slow to get underway in Europe generally (European Commission, 2015).

Within the European and Swedish construction sector progress has also been slow (European Commission, 2011a; Tykkä et al., 2010). However, within Sweden there are local examples of timber based multi-storey construction (ibid).

1.2 Timber building and conventional building

Timber based construction in Sweden is often associated with the term industrial building. In Sweden, the term industrial building is associated with offsite timber frame building with various grades of prefabrication (Brege, Stehn, & Nord, 2014; Gustafsson, Eriksson, Engström, Wik, & Serrano, 2012). This innovative building approach also known as modern methods of construction, offsite building, or system building in other countries (Pan & Goodier, 2012). Within industrial building, the extent of industrial processes can be categorized according to various grades of prefabrication such as the manufacture of volume elements (high degree of prefabrication), solid floor/wall elements of cross laminated timber (CLT) or simply component customer adapted timber beams (Brege et al., 2014).

There are various discussions in the literature about the exact definitions (Hedgren & Stehn, 2013). However this thesis is not concerned about the precise definitions but rather the transition from conventional construction to timber based building in Sweden. Accordingly the term timber building will be used.

Conventional building or traditional building, refers to onsite project-oriented construction using concrete frames (Hedgren & Stehn, 2013). Among Swedish clients, concrete building systems and its processes is generally considered the familiar, mainstream way of building or ‘the status quo’.

1.3 Sustainable Socio-technical transitions

In Sweden, around 90 percent of single housing is constructed with timber frames (Gustafsson et al., 2012). Regarding multi-storey housing, onsite concrete construction possess a similar market share. Major deep structural changes are required within the multi-storey construction sector if conventional building are to cope with the contemporary threats of global warming and resource depletion (European Commission, 2015).

Describing and analyzing major deep structural changes toward sustainability can be done through a number of common approaches such as neo-classical economy (developing a green economy), psychology (e.g. behavioral change) or industrial ecology (science and technology will deliver green solutions), each focusing on a specific dimension in transitions toward a sustainable society (Geels, 2012).

It is however unlikely that one single driver can answer to deep structural changes across a sector. In recent years much attention has been given to socio-technical theories, where sustainability transitions are explored with a broader approach, incorporating much of the economy and technological approaches above, and to a certain degree psychology through culture (ibid).

The socio-technical approach incorporate a system as several elements: policy, technology, markets, users, industry, culture and science, labeled as a socio-technical system and transitions are regarded as major shifts in these elements (Geels, 2004, 2011, 2012). Each element involves many actors, and the socio-technical approach highlights the interactions between these elements and its actors.

1.4 Knowledge gap

Within the Swedish construction domain and its research regarding multi-storey timber framed buildings, most studies tend to focus on technical aspects (Larsson, 2012). Other studies focus on industry actors. Roos et al. (2010) studied the influence and perceptions about multi-storey timber building among architects and structural engineers. The results indicate barriers exist at a cultural level (education, knowledge, normative beliefs) and that structural engineers and architects have low influence over material choosing. Hemström et al. (2011) found similar results in a questionnaire among Swedish architects highlighting attitudes where concrete is perceived more durable with regards to engineering aspects. Hedgren & Stehn (2013) looked at how clients make decisions regarding new buildings, and timber building. Policy measures in EU have been studied by Tykkä et al. (2010) and Swedish government report SOU 2013:12. Moreover, business models in Swedish timber building firms have been studied by Brege et al. (2014).

The previous research regarding timber building or innovation in the Swedish construction domain has focused on single dimensions of obstacles or improvements among specific actors. Ultimately, transitions involve many actors and they all need to agree on the need for change and cooperate in order to facilitate change (Larsson, 2012; Winch, 1998). As mentioned above, socio-technical theories incorporate multiple dimensions of change.

A specific model that considers multiple actors and their role in enabling complex transitions is the multi-level perspective (MLP) (Geels, 2002, 2004; Nykvist & Whitmarsh, 2008; ONeill & Gibbs, 2013; Smith, 2007; Walker & Shove, 2007). The usefulness of MLP when studying transitions have been showed in multiple sectors such as green building in the UK (ONeill & Gibbs, 2013), transport studies (Geels, 2012), mobility (Nykvist & Whitmarsh, 2008), sustainable housing (Smith, 2007), and electricity systems (Verbong & Geels, 2007). Accordingly, with this motivation, this thesis choses to investigate the transition towards multi-storey timber building from a MLP perspective.

A focus point in this research is to look at niches where public organizations have played a key role as a customer of construction projects (they are termed clients in the literature). The motivation for this focus is that public procurement is expected to play a key role in the transition towards the reduction of GHG. The European Union recognize that policy is not enough to stimulate innovation in the building sector (European Commission, 2011b). A new approach advocate that public procurement can play a key role in stimulation of innovation and sustainable new building approaches (European Commission, 2012; SOU, 2013).

1.5 Aims and objectives

This thesis proposes to introduce a socio-technical approach into assessing the Swedish construction sector and its developments. The intent of using the socio-technical approach is to contribute to a more holistic understanding of change. The overall aim is to assess how timber based building can become more mainstream.

Objectives within this overall aim are to:

1) Assess and reframe the literature about the Swedish construction sector, focusing on timber based building, from a MLP perspective.
2) Assess and frame timber based building niches, their origin and developments
3) Assess the momentum of these niches, with regards to a transition towards mainstreaming timber based building.

1.5.1 Focus and delimitations

1.5.1.1 Public actors and local governance

In Sweden, local government is strong and municipalities are responsible for matters relating to the inhabitants, including mandatory obligations for schools, elderly care, city planning, building and housing supply (Regeringskansliet & Finansdepartementet, 2008). Public housing companies (owned by municipalities) represent about 20 % of the housing stock in Sweden (SABO, 2014a) and are key investors in the construction sector, however there is little research about their role in stimulation innovation and new building approaches. Due to the strong local governance in Sweden, and the role of public actors, municipalities are a natural spatial limitation.

1.5.1.2 Multi-storey construction

Given the choice of these clients and the widespread use of timber in single-family homes in Sweden, this study is limited to the Swedish multi-storey construction domain. This domain considers new or modified buildings higher than two stories, either residential or normal sized industry or office buildings.

Before the data is presented this thesis firstly describes the socio-technical MLP framework. Thereafter the multiple research method is presented.

2 Theoretical framework

2.1 Introduction to Socio-technical theory

Deep structural transitions in society call for multi-dimensional theories since it is unlikely that it is only one driver that facilitate change (Geels, 2011). Socio-technical theories is broader than classical schools such as neo-classical economic viewpoints or psychology, and incorporate multiple dimensional aspects and interactions making it useful when studying transitions (Geels, 2012). The theories draw upon evolutionary economic science (trajectories, regimes, niches, path dependence, routines) and technology science (sense making, social networks, innovation shaped by broad societal contexts), structuration theory and neo-institutional theory (rules, institutions, duality, rules of the game) and is especially useful when studying sustainability transitions (Geels & Schot, 2007; Geels, 2004, 2011, 2012).

Socio-technical theory highlight the co-evolution and interactions of elements such as industry, technology, markets, policy culture and civil society (Geels & Schot, 2007; Geels, 2002, 2010, 2011, 2012; Nykvist & Whitmarsh, 2008). These elements form the socio-technical system. Every element has its own dynamics and actor groups within (ibid).

This thesis draw upon one specific approach in socio-technical theories, namely the multi-level perspective (MLP). MLP has never been applied on the construction domain in Sweden. One of the goals with this thesis is therefore to illustrate its usefulness and how the theory can be used to conceptualize and analyze the timber building development on a national and local scale.

The choice of MLP as a heuristic framework when analyzing deep structural changes within the Swedish construction sector is mainly motivated of its wideness and mix of several approaches. MLP go beyond a single technological or behavior fix and is broader than other traditional approaches. Its comprehensiveness and illustrative nature is of great value when analyzing the interactions between several dimensions in the construction sector. The analytical framework also allow for a broad assessment of the domain, as well as a detailed assessment of local developments.

The MLP is an analytical concept, and it is the empirical topic that determine on what level the analysis should be conducted. In this thesis the empirical topic partly include the national context and partly local timber niches residing within municipalities. Therefore part of the analysis is conducted at a national level, drawing on secondary empirical observations.

2.2 The multi-level perspective

2.2.1 Socio-technical systems

The socio-technical *system* consists of several heterogeneous elements or dimensions; industry, technology, markets, policy culture and civil society with various actor groups within each element (Geels & Schot, 2007; Geels, 2004, 2010).

Socio-technical systems have lock-in mechanisms that stabilize them from transitions. Such lock-in mechanisms may be heavy investment in machines, economy of scales which create cost competitive advantage, infrastructure and competencies. Additionally, institutional commitments, shared beliefs and discourses (creates thinking inside the box), power relations and political lobbying create entry barriers that stabilize the system further. (Geels & Schot,

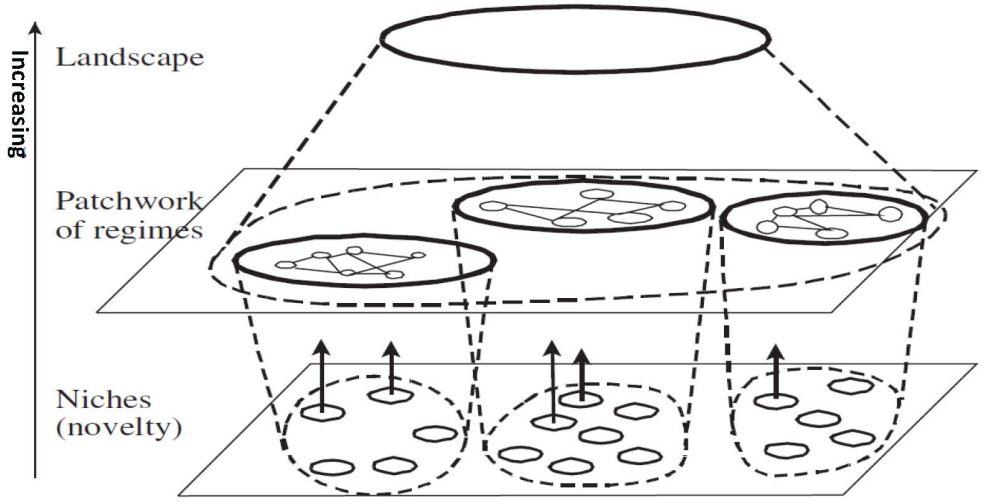
2007; Geels, 2011, 2012; Nykvist & Whitmarsh, 2008). Therefore, innovation typically is incremental and along trajectories within the elements. Thus, it is path dependent.

2.2.2 Conceptualized in three levels

The multi-level perspective (MLP) argues that socio-technical systems consist of three hierarchical levels, namely *niches*, *regimes* and *landscapes* (see Figure 1 below). Niches are where radical innovation emerge, and the regime relate to established practices and rules (Geels, 2012). The socio-technical landscape is the exogenous context that affects both niches and regimes (ibid). The hierarchical arrangement of niches, regime and landscape refers to different stability in these levels, where higher levels are more stable considering number of actors and degree of alignment between elements (Geels, 2011). An existing socio-technical system (niches, regimes and landscape) are characterized by lock-in and stability and path dependence, resulting in incremental change along trajectories (Geels, 2012).

The socio-technical *regime* refers to the deep structural rules, 'the rules of the game' that guide and coordinate regime actors' perceptions and actions. It can be said to be the cohesive factor between the elements (the mainstream way of doing thing). The regime is the central concept, and niches and landscapes are defined with the regime in consideration.

Niches are the locus for radical innovation, and its practices and technologies deviate substantially from the regime. The socio-technical *landscape* is the exogenous broader context, macro changes that influence the dynamics of the socio-technical regime and niches. Figure 1 shows the conceptual levels of MLP and the hierarchical structure of increasing stability with each level.



2.2.2.1 Figure 1. The multiple levels in MLP with increasing stability (Geels, 2012)

2.2.3 Niches

In MLP, radical innovation often emerges in niches. Niches are practices or technologies that deviate from the existing regime (Geels, 2011). Niches can exist in protected spaces such as R&D laboratories, subsidized demonstration projects, or small market niches (Geels, 2012). Niches may include new technologies, institutions, markets, lifestyles and cultural elements and operate in the outskirts or outside the socio-technical regime (Nykvist & Whitmarsh, 2008). The innovative nature of a niche results in uncertainties and unstable routines, but as a niche develops over time so does its routines and configuration.

2.2.3.1 Niche development

Three core processes regarding niche development can be noted: (Geels, 2011, 2012)

- Expectations or visions. Articulation of expectations aims to attract investors for external funding, and also provide strategic guidance to innovation activities.
- Social networks. Building new networks and involving more actors expands the social and the resource base of niche novelties.
- Learning and articulation processes. Valuable lessons are being learned of niche actors regarding technical design, market demand, user preferences, and appropriate business models. Also experience regarding infrastructure requirements, organizational challenges and policy.

2.2.3.2 Niche momentum

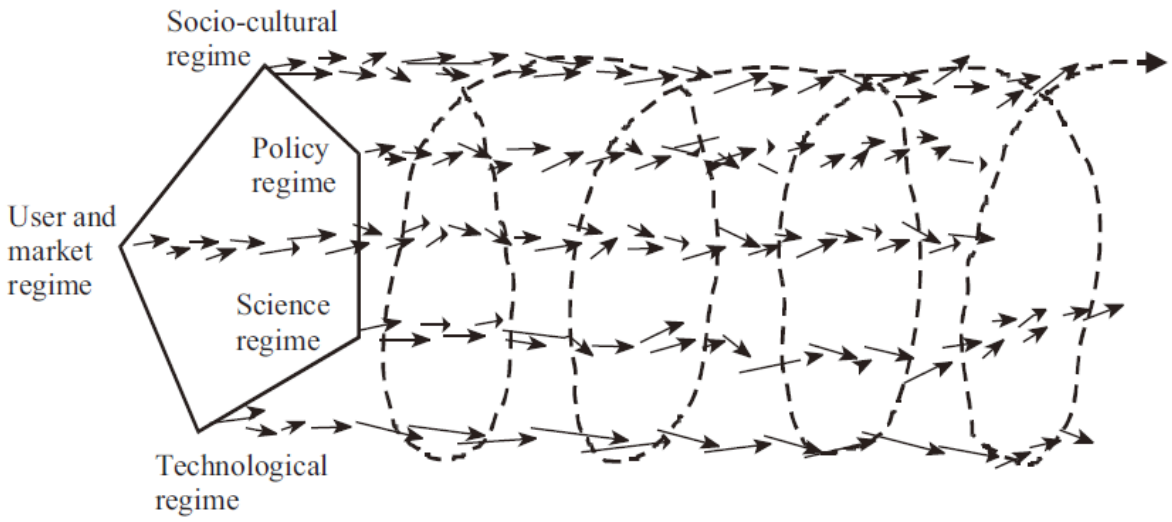
Momentum refers to the 'strength' of a niche in facilitating a transition in the socio-technical regime. Niches gain momentum if visions or expectations become more precise and broadly accepted. Momentum can also be gained when lessons align in a so called "dominant design", or stable configuration, or when networks grow large and more powerful actors start to participate. (Geels, 2012)

Niche actors hope that the innovations eventually will be adopted in the regime, or even replace it. Few niches succeed in this, due the regime lock-in. Niches may not be able to build up sufficient momentum, have set-backs or fail to overcome barriers due to regime lock-in (Geels, 2012; Smith, Voß, & Grin, 2010) The various transition pathways are presented in detail in the section 2.3.2.

2.2.4 Socio-technical regime

The socio-technical regime comprises dominant practices, rules and shared assumptions, or the mainstream way of currently realizing societal functions (Nykvist & Whitmarsh, 2008; Smith et al., 2010). The precise definitions of regimes vary, although the fundamental concept is the same (Nykvist & Whitmarsh, 2008; Smith et al., 2010). In this thesis, the notion the socio-technical regime refers to the deep structural rules that account for stability in the socio-technical system (Geels, 2004, 2010, 2011, 2012). It is the 'rules of the game', the 'rule of thumb'. This contributes to stability in the system by guiding and coordinating the actor's perceptions and actions. These actors exist in the elements technology, industry, science, markets and users, culture and policy. It is the rules that make these elements (and its actors) semi-coherent and more or less aligned. Thus, the socio-technical regime concept aim to capture the coordination of the actors within the elements (Geels, 2011)

Figure 2 shows the socio-technical as sub regimes, or elements, with their own dynamics. The figure highlights the co-evolution between these sub regimes, and show that internal dynamics within the socio-technical regime can provide additional stability if aligned, or destabilize of not aligned (Geels, 2011)



2.2.4.1 Figure 2. Alignment of continuous processes in a socio-technical sub regimes. Adopted from (Geels, 2011)

The use of the word regime may be somewhat confusing in this picture. It is used to highlight that each of the elements technology, industry, science, markets and users, culture and policy can be further detailed as sub-regimes, with its own set of actors. For example within the technology element, various technology actors reside and there is not one single way of constructing concrete buildings, but several technical solutions such as prefabricated concrete elements or site mixed concrete. The elements also co-evolve and affect each other (policy is one common way of affecting the dynamics of the regime), where they can align and add stability or misalign and create tension.

Innovation within the regime tends to be incremental and along trajectories within the elements, thus existing regimes are characterized by lock-in and path dependency. Niches are seen as a place where radical innovations can exist, and niche actors hope to facilitate a transition in the regime (growing a new regime with the niche innovation included) (Geels, 2002, 2004). Thus, regimes are influenced by niches every once in a while, though facilitating a change in the regime is hard due to lock-in and few niches succeed.

Both niches and regimes are influenced by macro pressures from the socio-technical landscape. The next section will describe this exogenous context. Then the dynamics of the socio-technical system is further elaborated in multi-level dynamics section 2.3.

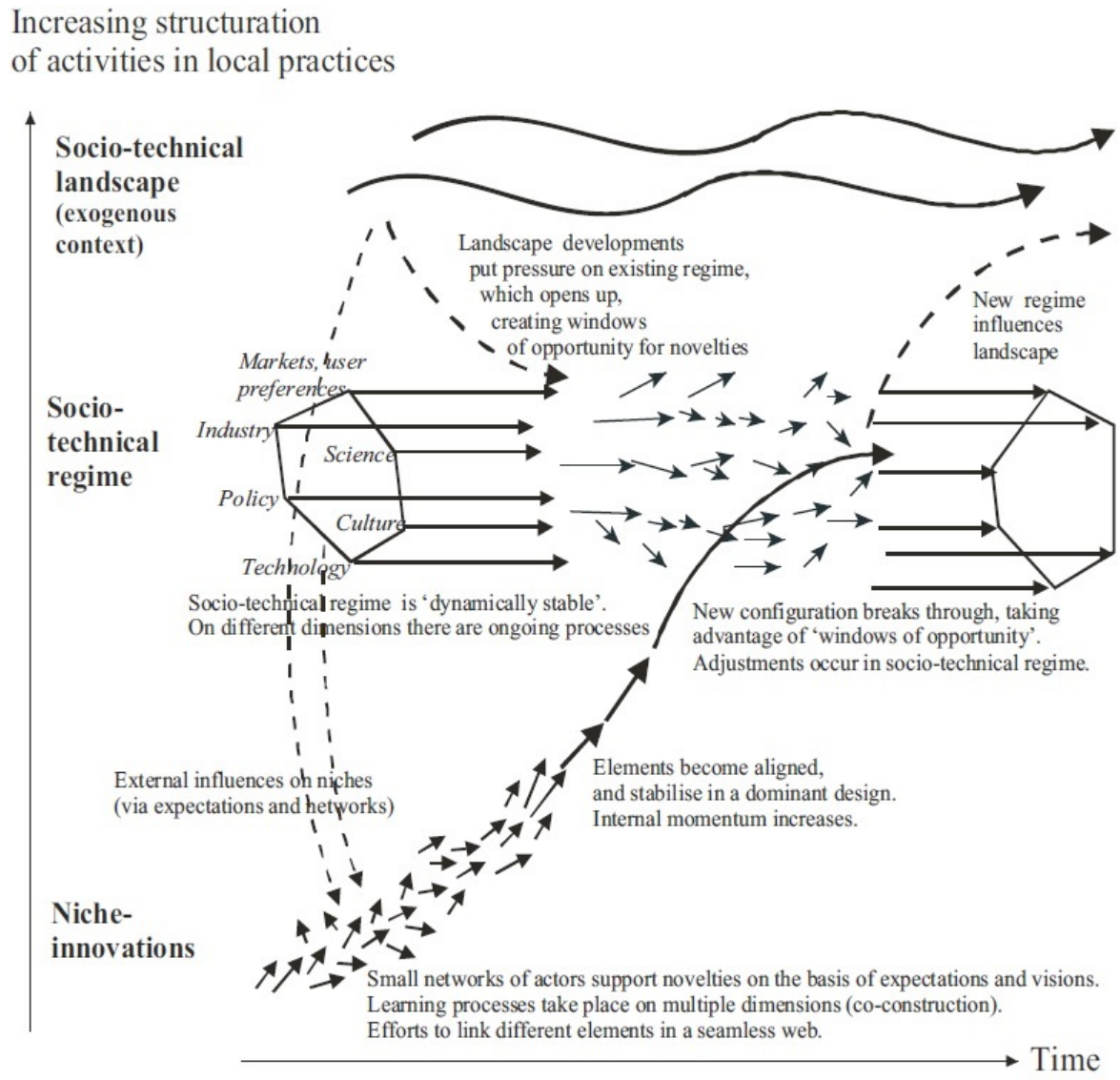
2.2.5 Socio-technical landscape

The landscape is the slow changing, wider context that affects the dynamics of niches and regimes (Geels, 2012). The landscape not only consist of the regular technical and material components that comprise society, but also of demographic trend, societal values, political ideologies and macro-economic trends (Geels, 2011).

Landscape change is a source of pressure at the regime level, which can create opportunities for niche developments or making a regime realign. Typically, when the socio-technical landscape changes, the regime is slow to adapt which create room for niches to advance (Nykvist & Whitmarsh, 2008). A window of opportunity where niches can advance may occur in the regime as result of landscape pressures or internal dynamics in the regime.

2.3 Multi-level dynamics and interactions

The multi-level perspective involves multi-level interactions between the socio-technical landscape, socio-technical regime and niches. Transitions (such as the industrial revolution) historically span over a long temporal period (Geels, 2012; Smith et al., 2010) and are defined as a radical shift from one regime to another. Figure 3 below illustrates the multi-level interactions in MLP and potential transition pathways. In short radical transitions build upon the interactions on three hierarchical levels: 1) niches build up internal momentum 2) landscape developments put pressure on the regime 3) destabilization in the regime create windows of opportunities for niche innovations. (Geels, 2012).



2.3.1.1 Figure 3. Interaction in MLP facilitating a transition. Adopted from Geels (2012)

Fig. 3 depicts how the three levels interact dynamically regarding socio-technical transitions. It highlights processes at different levels and its interactions. Arrows represent trajectories, or the path dependencies. Downward arrows also indicate that the landscape and regime influence the perceptions of the niche-innovation actors. Processes on multiple dimensions

link up and enforce each other, so called circular causality. Therefore, there are no single drivers in MLP.

Figure 3 is an ideal representation of transitions in MLP and there is no guarantee that niche development will succeed. Niches may fail to build up sufficient momentum or the window of opportunity may remain too small. (Geels, 2012) It is however an important illustrative picture of the interactions on different levels in MLP, incorporating niche developments, landscape pressures and regime dynamics. Section 2.3.2 below elaborates on the different transitions pathways, with regards the timing and nature of the interactions shown in Figure 3.

2.3.2 Transition pathways

Transitions are defined as a shift between one regime to the next, why niches and landscape development are defined in relation to the socio-technical regime. Moreover, the MLP can be differentiated in four transition pathways, drawing on the timing and the nature of transitions. (Geels & Schot, 2007). *Timing* refers to landscape pressure on the regime with regards to the development of the niche innovations. For example, if a landscape pressure occurs when niches are not fully developed, transition will take on a different path than it would have if niches were fully developed. The *nature* of multi-level interaction refer to the relationship as competiveness or symbiotic.

For example, a niche-innovation may have a competitive nature or symbiotic nature towards the regime. A symbiotic relationship could be adopted as competence-enhancing add-on in the regime to improve performance. Competitive relationships instead aim to replace the regime. Using the timing and the nature of the niche-regime relationships, four transition pathways can be illustrated (Geels & Schot, 2007).

2.3.2.1 Transformation pathway

When landscape developments put pressure on the regime and niche-innovations are not yet well developed, a regime transformation may occur. This result in regime actors modifying the direction of developments and innovations along regime element trajectories. Regime actors may import symbiotic niche-innovations as add-on, but in the end there is no radical change in the regime.

2.3.2.2 Technological substitution pathway

Technological substitution can occur when niche-innovations are well developed and have a strong momentum, and sudden strong landscape pressures put pressure on regimes. Niche innovations then break through a window of opportunity and replace the technology element in the existing regime. For example, steam engines developed in niches protected from the sailing regime in 1850s and 1860s. When mass emigration to America occurred together with the opening of Suez Canal, steam ships totally replaced the sailing ships due to performance and cost competiveness on long distance voyages. This pathway often leads to a downfall of incumbent firms. The niche innovations compete with the existing regime, and market competition and power struggles between new and old firms exist.

2.3.2.3 Reconfiguration pathway

Reconfiguration is a transition where niche-innovations are more developed when landscape development put pressure on the regime. Niches can then use their momentum to explore the window of opportunity, and if niche-innovations are symbiotic to the regime, regime actors can adopt them to solve local problems. New component suppliers compete with existing

component suppliers. When regime actors adopt new niche innovations, the rest of the regime can subsequently adjust in its basic architecture.

2.3.2.4 De-alignment and re-alignment

De-alignment and re-alignment is when the regime collapse due to landscape pressures. When this happens multiple niches emerge and compete and eventually one niche innovation builds up significant momentum leading to new regime. For example, when the horse drawn carriage regime collapsed due to landscape pressures (hygiene concerns, urban expansion, and high cost of stables) multiple niches competed against each other. Electric trams, electric vehicles, bicycles and automobiles were all niche innovations simultaneously competing to become the new regime. However when the T-Ford established a dominant design (serial production) then the auto mobility regime eventually established around this innovation (ibid).

2.4 How MLP is used in this thesis

The theoretical framework is used on two levels in in this thesis. First, the national construction sector is considered with regards to timber building. This is labeled as Stage 1, and the empirical topic focus primarily on the socio-technical landscape and existing regime.

In stage 2, the empirical topic includes timber building municipalities, considered as niches. Thus the focus is on niche development and niche momentum.

3 Research methodology

The method section starts with a philosophical discussion on methodology of science. An introduction and motivation to the choice of case studies is then presented, followed by motivation and choice of research approach.

3.1 The methodology of science

There is an established consensus that science is to be defined at the methodological level, although current science philosophers disagree about the nature of this method. At the lower levels of data collection, there are well established methodologies. For example in clinical tests there are recognized methods such as random trials or double blind tests. However, a much debated area of scientific methodology is the evaluation of theories and theory construction. Since the scientific methodology varies depending on the historical time period, culture or research field, a common view at present time is that the scientific method is broad guidelines including a wide array of techniques, rules and procedures. (Curd & Psillos 1965, 2014)

A couple of broad methodologies can be outlined when it comes to theory construction or approval. Three of these methodologies are discussed below. In the following section, the chosen approach for this thesis is presented.

3.1.1.1 Naive inductivism

One frequently used perspective on how to conduct science is the naive inductivist view. This methodology is a classics empiricist approach essentially a two-step procedure where theories are constructed on the basis of observation. The first step is to collect empirical data from the domain. In the second step, inductive generalization is applied to the data, trying to form laws or theories that are presumed to be valid for a larger set of data than originally studied. Although the naive inductivism has been practiced in the history of science it has some fundamental problems.

The first problem that occurs is the objectivity of observations, where observations need theory to make sense. In order to collect or even identify data, the researcher is required some prior knowledge, meaning that theory must be present and that science cannot begin with just collecting observation and then proceed to theory. The second problem with naive-inductivism presents itself when investigating (at the time) unobservable objects, for example electrons or strings in the string theory. These unobservable objects are often foreseen with the formulation of a theory, not the other way around. In short, the naive inductivism lacks the resources to deal with this. Thirdly, it's hard to justify the use of induction in a rational way. It is not a form of deductive inference, thus it is hard to use this approach to justify the method. It's also hard to draw on the historical success of the method since this would be to use the inductivism to prove the theory itself in a circular manner. (Curd & Psillos 1965, 2014)

3.1.1.2 Hypothetico-deductive method

A second common approach is the hypothetico-deductive method, or the method of hypothesis. According to this perspective, theories are to be evaluated by testing the predictions they produce. True predictions confirm a theory, false predictions disconfirm a theory. The theory is justified when the observational consequences are controlled, in this way, the method uses induction for justification rather than formulating new laws or theory.

The hypothetico-deductive method avoids the first two mentioned problems of naive inductivism, discussed above. However, one problem with this method occurs when deriving the predictions. The theory states a universal generalization, and deriving a prediction is hard without the specific context in where the generalization applies. It is also hard to test the prediction isolated from the all other empirical assumptions. Another problem that occurs when relying solely on controlling predictions from theories, is that if two or more theories have the same prediction, they might get the same support from the empirical observations even though one or more of the theories is irrelevant. Recent attempts to modify this method emphasize the *explanatory role of hypothesis*. If a hypothesis can be shown to be the best available explanation, then this fact is a motive to prefer the hypothesis to alternative hypotheses which provide lower-grade explanations. (Curd & Psillos 1965, 2014).

3.1.1.3 Popper's falsification theory of method

A third approach is Popper's falsification theory of method. This method makes no use of induction and therefore avoids the problems described above. The falsification theory of instead argues that method trial and error is the method of science. With this method, scientists present bold speculative theories and rather to support them with experience, scientists seek to disprove theories with rigorous tests. A theory is valid if the tests succeeds and accepted as the best available at the time. This method is sometimes called deductivism since it rejects all form of inductive methodology. Critique to this method is that it may be overly hard, and elimination of theories is not norm in actual science. A theory does not necessarily need to be rejected and dismissed when failing a test, it may simply be further investigated. (Curd & Psillos 1965, 2014)

Many philosophers at present time hold a pluralist conception of scientific methodology, meaning that there is no single scientific method but rather several rules which may be used to evaluate theories (Curd & Psillos 1965, 2014). The author of this thesis is of the same opinion in this matter. The lack of consensus among the researchers motivates the section above and shows the importance of reflection on these issues when conducting research. The above mentioned inductive, semi-inductive or pure deductive research methodologies all emphasize generalization, which is a traditional natural-science assumption. However, there are other skills than generalization involved in knowledge creation.

3.2 Chosen research approach

Since the identified research area originates from a specific theory, the naive inductive method has been ruled out. Nor has there been an attempt to falsify the MLP theory such as with the Popper's falsification theory of method. Instead, the hypothetico-deductive method is outlined the broad methodological work in this thesis. Seen from this perspective, the thesis tries to justify the theory through a number of observations.

Case studies was chosen as the appropriate research approach, due to the largely context dependent phenomena studied. The case study method is an suitable form of research when studying specific contexts, (Flyvbjerg, 2001). Similarly, Yin (2003) motivates the use of case studies when a phenomenon to be studied is difficult to distinguish from the context at large. The practical choice of studying niches, public actors and their role in transitions cannot be distinguishable from that actor's context. Moreover, detailed examples of perceptions and experiences were required in order to fulfill the research aims. Accordingly, with this motivation, case studies was chosen as a research approach (Flyvbjerg, 2001; Gillham, 2010; Yin, 2003). Moreover, the theoretical framework emphasize complex dynamics such as

multiple dimensional interactions, path dependencies, barriers etc. and it is therefore hard to apply other methodologies such as standard regression techniques or comparative methods.

Moreover, this is a multiple method study regarding data collection, and both semi-structured interviews and document sampling have been used. This is further motivated below in methodology regarding research stage 1 and 2.

The method choice of case studies draw on Flyvbjerg (2001) since that author has contributed to the case study methodology with literature and importantly case studies of the building sector. In these specific contexts, the closeness to reality and thorough details of a case is important in two aspects; firstly, the view of reality is nuanced, meaning that human behavior cannot only be understood with simplistic theories. Second, it is important for the researchers own learning process, where actual experience from the context helps focusing the research on content rather than form. Case studies are therefore especially well-suited for producing concrete context-dependent knowledge. (Flyvbjerg, 2001)

"The advantage of the case study is that it can close in on real-life situations and test views directly in relation to phenomena as they unfold in practice". Case study scientists often report that studying a few cases intensely often lead to the insights that assumptions, concepts or hypothesis are wrong and needs revision." (Flyvbjerg, 2001)

The quote above highlights the value of detailed knowledge and the usefulness of the acquired knowledge. In social sciences, Flyvbjerg (2001) argues that generalization is just one of many skills a researcher should possess, and science is in the essence about creating knowledge. He does not criticize formal generalization, but argues that other approaches such as the power of pure example in case studies often are underestimated. Flyvbjerg also emphasize the importance of phronesis, or practical knowledge. He argues that as the scientist achieves higher levels of knowledge, i.e. learns from the studied context, researchers gain insights that lead to reformulation of theories or concepts. Thus, the case studying is a form of emerging research method.

3.2.1 Research in two stages

The studied phenomena are extensive, holistic and complex, which motivates a division of the research into two research stages. First, the theoretical concept of socio-technical regimes and landscape are used to structure data in stage 1. This data is collected on a national empirical level, drawing on a literature study. Second, the theoretical concept of niches and their developments within the construction sector are presented in research stage 2.

The analytical framework allows for analysis at different spatial levels. Multiple methods have therefore been used when collecting data. The use of different methodological viewpoints is known as triangulation (Gillham, 2010) and can, if the results converge, add to the validity in the study due to the observations can verify and validate each other (Bryman, 2011).

The two stages conducted are outlined in Table 1 below, and described in more detail in the following subsections. In the first stage, observations from web based material and relevant literature were collected. The purpose of this has been to gather an understanding of the studied domain, since the analysis require in depth knowledge and creativity in order to be useful. With this motivation, the aim of introducing the multi-level perspective (MLP) into the Swedish multi-storey construction domain has been accomplished using secondary data.

Research stage 2 build upon multiple case studies, with primary observations gathered through semi-structured interviews and at conference hearings. Table 1 below shows the different stages, purpose and chosen methods. A more detailed description and motivation of method choice is presented in the following subsections.

3.2.1.1 Table 1. Purpose and methodology for the two research stages used in this thesis

Research stage	Aims	Methodology
One	Frame the national construction context through MLP	Literature study of web based material and the literature
Two	Assess and frame timber based niches, their origins and developments.	Multiple case study with primary data, semi-structured interviews and conference hearings

3.3 Researching stage 1

The methodology in stage 1 aimed to ensure that the results would assess and reframe the literature about the Swedish construction sector using MLP, focusing on timber based building. The literature study also enhanced the author's knowledge of the Swedish construction sector, and set the context for assessing and framing timber based niches (stage 2).

3.3.1 Data collection

A purposive sampling framework was used when searching for relevant documents. Every article was judged based on its expected information content regarding the studied phenomena. This is especially useful when working for a rich understanding and a small sample (Symon & Cassell, 2012). Three strategies have been used when conducting the literature review. These three strategies are presented and motivated below.

- *Strategy number one:* Business administration literature published by authors that's concerned with adopting timber based construction in Sweden. The motivation for this is that construction traditionally is considered to be a local activity.
- *Strategy number two:* Key contributions to the general understanding of the issue of innovation in the construction sector including transitions to timber based building methods.
- *Strategy number three*: Swedish government reports addressing the building sector including statistical data and governmental institutions.

Data have been collected from published peer-reviewed journals, published books, PhD work, institutional databases (EU and national databases) and webpages. The document search was mainly performed electronically, in databases such as google scholar, Elsevier, and SLU and Uppsala University electronic libraries. Moreover, some data in stage 1 can be classified as primary data and were collected in two conference hearings. Data search was limited to the years 1998 to 2015. Search words was adapted throughout the research process, and initially included words such as multi-storey timber building, timber building, timber-frame building, building systems MLP, Multi-level perspective, socio-technical transitions. References in published literature were also used when obtaining secondary data.

3.3.2 Stage 1 data analysis

The collected data material has been subjected to *content analysis* where observations where interpreted, compared and then sorted (Denscombe, 2007; Silverman, 2005). In stage 1, the empirical topic included the national multi-storey construction sector. The theoretical framework concepts of the socio-technical regime and landscape were used to organize and assess the obtained data. Within the socio-technical regime, data gathering focused on the elements industry, technology, policy, science, markets, user preferences and culture. These categories have been the structure of the results in stage 1 regarding the socio-technical regime and the socio-technical landscape.

The MLP theory has been used as framework for analyzing the data gathered in a structured way. This framework is not a 'truth machine' that automatically analyze the data when entered, instead it is heuristic framework that guide the analysis towards relevant questions and problems (Geels, 2011). Thus a large part of the analysis in stage 1 has been to illustrate the construction domain, especially the socio-technical regime and the socio-technical landscape. This set up the point of departure for the detailed cases of public actors and timber niche developments.

3.4 Researching stage 2

Stage 2 builds upon the theoretical concept of niches and their development and momentum. Three cases were chosen based on their expected information content regarding timber building development. First step was to identify a case population of timber building niches, which is detailed in Table 2.

3.4.1 Case population

The requirement for qualifying to the case population of timber building niches was that it was a Swedish municipality or significant actor with recent timber building developments. Furthermore the case needed to be mention in online literature studied in stage 1. Singe actors where later eliminated as potential cases due to the limitation related to the role of public actors. Snowballing techniques were then used in order to secure that no innovative and significant municipality was left out, and also to identify interview respondents within the cases.

The strategy for identifying the case population is motivated by the theoretical notion that niche actors network (see theory section 2.2.3.1). As a student of SLU the author previously attended seminars organized by the Swedish Forest Industry Federation and the network Trästad has also participated in these seminars. Trästad is a national network open for municipalities, clients and provinces in Sweden, sharing their experiences regarding timber building (Trästad, 2015). All leading municipalities are assumed to participate in this national network. A program from the first seminar attended, see Falu Kommun & Trästad (2014), form the basis for the case population. This case population is presented in Table 2.

Table 2. Procurement actors and expected information content

Clients known to purchase timber buildings	Expected information content
Växjö municipally	One of the leading municipalities when procuring multi-story housing. The first municipally to adopt a wood building strategy. Member of networks such as Trästad, CBBT and Nordic Wooden Cities. (Nordiska trästäder, 2015b; Westerlund, 2012; Växjö kommun, 2014)
Örkelljungabostäder AB	One local municipal housing company procured a six storey wooden framed house in 2010. The house was built by Åsbohus and Martinsons. (Bostäder, 2014; Martinsons, 2014; Åsbohus, 2014)
Skellefteå municipally	Skellefteå municipally is one of the leading municipalities in wooden construction. This municipally has a new wood building strategy, where wood is considered during tendering. Älvsbacka strand and Älvsbacka Park has considerable amounts of wooden buildings. Active member of the networks Trästad 2012 and Nordic Wooden Cities (Nordiska trästäder, 2015b; Skellefteå Kommun, 2014; Westerlund, 2012)
Falu municipally	Falu municipally has the ambition to be at the frontier when it comes to building with wood. They promote a number of demonstration projects, most notably an innovative procurement project together with EU and Norwegian municipally Lyngdal. Falun has a wood building strategy and is a member of network Trästad 2012.
Skövde municipality	Member of Trästad 2012 and planning to build wooden housing in the neighborhood Frostaliden. (Skövde Kommun, 2012, 2014).
Rikshem	One of the biggest private owned housing companies in Sweden. In a joint venture, Rikshem and Folkhem are planning on procuring 4000 apartments in Stockholm until 2020. All build with wooden frame. (Rikshem, 2014; Sundström, 2014)
Folkhem	Folkhem is a medium sized enterprise, recently known for building Strandparken, Sundbyberg. Working with Rikshem in the JV "Folkhem Trä" building 4000 apartments in Stockholm, see Rikshem above. (Fastighetsvärlden, 2014; Folkhem, 2014)

3.4.1.1 Case selection strategy

The overarching case selection strategy was to work with information-oriented cases, with focus on municipalities in Sweden with relevant public procurement practices. The purpose of this selection strategy was to maximize the value of the information from small samples or a few cases (Flyvbjerg, 2001). The cases were chosen based on the expectations of their information content. These expectations are motivated further above in Table 2.

Cases that are information-oriented can be further divided into sets:

1. *Extreme cases* which are an especially good illustration of change (Flyvbjerg, 2006). Pioneering actors often possess a more critical view and a deeper level of experience with issues, including how to overcome barriers to change (Rogers, 2003).

2. *Paradigmatic cases* which are useful for developing a metaphor and are likely to highlight more general characteristics of the area in question (Flyvbjerg, 2001). This case selection criterion includes procurement actors who are accustomed to the mainstream way of constructing multi-storey residential building.

Three extreme cases and one paradigmatic case are included in this thesis.

3.4.1.2 Case selection criteria

Three extreme cases were chosen from the case population in Table 2. First, private actors were ruled out due to the research aim of public actors. Second, one case was chosen as a preliminary case based on its pioneering work of developing timber building within the municipality. This case was Växjö, and was chosen from the case population due to its active involvement in national network such as Trästad and Nordic wooden cities, and due its vast number of demonstration projects mentioned in literature encountered in stage 1 research.

Second, Falu municipality was chosen as an extreme case due to its involvement in national networking and its innovative work regarding public procurement, mentioned at the first seminar the author attended early in the research process. Thirdly, Skellefteå was preliminary chosen due its general appearance of a timber building municipality in encountered literature, and its involvement in Trästad and snowballing.

Snowballing technique was used to verify that the preliminary choice of cases was perceived as pioneering actors within the public actor network. This technique was deemed viable since the theory highlight the importance of networking in niche development, see theory section 2.2.3.1 for more details. One assumption therefore is that respondents within public timber building clients have knowledge about other leading actors.

One paradigmatic case was also chosen, Hammarö municipality. This case was identified through the informal networking contacts of the author. The case population consisted of all municipalities with of equal of smaller size of the extreme cases due to a limited research time. Moreover, the chosen paradigmatic case was intended to nuance the view of the national construction domain presented in in stage 1 results, and not intended to contribute to the timber building niche results. Therefore, the paradigmatic case is presented as an outlook in stage 1 results.

3.4.2 Snowball technique – case and respondent selection processes

First, snowballing techniques was used to ensure that the cases chosen were extreme cases, or pioneering actors. Second, in order to find respondents within the selected cases, the interviewees have been asked to recommend interviewees in the other cases.

Snowball sampling is a method of finding new participants by cooperating with already enrolled participants (Bryman, 2002; Powers & Knapp, 2010). This means that sampling of actors took place in sequence. In this case, interviewees were asked to suggest other actors and respondents who possibly could contribute with knowledge to the studied phenomena.

The first interviewee was located at the seminar attended in the beginning of the research process. Discussions were also made with known researchers in the area about suitable respondents and cases. Key client actors were then identified by snowballing directly through this first respondent, and through contacting the offices of the chosen municipalities with a topic description. Respondents were then contacted directly and briefed about the research purpose and aims.

Due to purposive sampling and snowballing techniques, the respondents all had significant knowledge and experience about each case and the construction industry in general. They also held high formal positions in their organization or were specifically employed for working with timber building questions. The extreme case interviewees were also involved in national networking and local politics regarding timber building.

3.4.3 Case data collection

Strategies for collecting case data were:

1) Semi-structured interviews with key client actors
2) Web based survey of client actors homepages and the municipalities web pages
3) Data from the stage 1 literature review, see above.

3.4.3.1 Data collection from semi-structured interviews and web based sources

Four interviews with five respondents were conducted using a semi-structured interview form. Semi-structured interviews is a interview form that is suitable for qualitative research and ensure a flexible interview with the possibility to elaborate on interesting turns, but with maintained relevance to the research questions (Bryman, 2002). The respondents all had significant knowledge about local timber building practices, which was ensured by snowballing selection and purposive sampling.

The persons that participated in the interviews were:

- Olle Wiking (Real estate manager, at Falun municipality, Falu Case)
- Hans Andrén (Project coordinator VKAB, member of CBBT, Växjö Case)
- Rolf Andersson (Project leader Trästad, Project leader Public Administration, Skellefteå case)
- Samuel Forsman (PhD Luleå University, Project leader Trästad, Skellefteå case)
- Jan Barthelson (CEO Hammarö bostäder, Hammarö case)

The interviews were face to face in first hand and as a second choice conducted over telephone. Two thirds of the interviews were conducted face to face. The first hand choice of face to face interviews were motivated by the increased connection with the interviewee through body languish and the possibility to react to this with follow up questions (Bryman, 2002). The interviews were also recorded in order to improve the analysis of the answers. Recording contributes to enhance the memory and enables the researcher to work through the answers several times (ibid). Interviews were transcribed, summarized and checked with the respondent in order to verify the accuracy.

An interview guide was primarily followed, see Table 3 . If the respondent changed direction in the interview the themes were rearranged in order to create a natural flow. The respondent was allowed to elaborate and follow-up questions were asked when appropriate. The follow-up questions were intended to add details to the answers. Examples of follow up questions include ‘How do you mean?’ and ‘that is very interesting, could you elaborate?’ (Bryman,

2011). Moreover, direct, indirect, structuring questions were asked for extensive answers (ibid).

The semi-structured interview guide with its questions was constructed with the theoretical frame of reference in mind. Question formulation based on open ended questions Bryman (2002). Table 3 shows an example of theory and thereby theme, purpose and examples of interview questions.

Table 3. Thematic interview guide with examples of interview questions, their purpose (according to the theory) and grouping under theory themes.

Theory and theme	Purpose	Example of interview questions
Articulation of visions	*Identify visions and expectations. Identify how precise and broadly accepted they are.*	What issues do you see with contemporary building approaches? What goals do you have? What visions? Why are interested in timber building? Why you? Why not others??
Networking processes	*Identify networking activities and their importance, size and missing actors.*	Who do you network/ cooperate with? Is networking important? Why? Do you miss any actors? How do you perceive the interest for these networks?
Learning processes	*Identify valuable lessons learned and indications of dominant design. stable the configuration is*	What lessons have you learned? How do you encourage innovation? Are there routines for your work? Have there been barriers and how have these been overcome?

Secondary data have been used in stage 2 as well. Web based sources have been used with similar requirements as in stage 1. A purposive framework was used when searching for relevant documents. When the primary data was estimated insufficient, the data was complemented with web based sources.

Web based data have mainly been collected from actor webpages. Some peer-reviewed journal data have also been used. The document search was mainly performed electronically, in databases such as google scholar, Elsevier, and SLU and Uppsala University electronic libraries, see section 3.3.1

3.4.4 Stage 2 data analysis

Similar to stage 1, the data collected in stage 2 has been subjected to *content analysis* (Denscombe, 2007; Silverman, 2005). The data has been assessed according to the theoretical framework and presented accordingly. For all cases a tentative analysis assessed whether the MLP framework was appropriate. For the three extreme cases it was appropriate, whereas for the paradigmatic case it was not.

The results for the three extreme cases were structured and assessed according to this theoretical structure: 1) Articulation of expectations and visions 2) Networking processes and 3) lessons learned and 4) niche momentum. These specific categories originate from the theoretical framework and have been used for of analysis in stage 2. The primary source of data in Stage 2

was semi-structured interviews. The observations transcribed and then coded in the content analysis (Denscombe, 2007; Silverman, 2005). Table 4 below show an example of this.

Table 4. Illustration of the structured content analysis of transcribed semi-structured interviews. Fat marking indicate the corresponding theoretical term.

Examples of respondent speech excerpt	Theoretical terms
"We have worked with this local timber building strategy starting already in 2012 and finished it during 2014"	Articulation of expectations or visions - **Attracting actors through visions and expectations** - Guide innovation activities
When they are building a school in Vansbro or Malung, we should collaborate so they got our competence	Processes for building new networks and involving more actors -**establishing networks** -enrollment of more actors, i.e local industry
"Yes I would say barriers have been overcome in all the technical aspects; fire, stabilizing constructions, wind, vibrations, acoustics and subsidence."	Learning and articulation processes on various dimensions - **Technical learnings** - Market learnings - Business models - Organizational - Policy

The transcripts from the semi-structured interviews were read multiple times and specific paragraphs, sentences and clauses were identified as shown above in Table 4. The fat marking indicate the identified corresponding theoretical term from the quote on the left side.

For the paradigmatic case the niche development framework was not appropriate. The practices and innovations in the paradigmatic case were judged incremental. Thus it did not deviate to the existing regime, and therefore the niche development framework was ruled out. Instead the data gathered in the paradigmatic case has been framed using other parts of the MLP model, namely the landscape and regime concepts. Content analysis has still been applied to the results, but the theoretical framework used considered regime characteristics and multi-level dynamics rather than niche developments.

3.4.5 Ethical considerations

Ethical considerations mainly involve the anonymity of primary sources of information (respondents) and the confidentiality of the material. The respondents was ensured to proof read the results previous interviews, adding to the validity of the observations since respondents feel safer (Trost, 2010). The respondents also had to agree with the use of a recording device. The primary observations from the semi-structured interviews have not been deemed as sensitive or confidential which has been ensured by allowing all respondents to proofread a draft before publishing.

3.5 Validity, reliability and bias toward verification

3.5.1 Bias toward verification and generalizing

Bias toward verification applies to all scientific methods, case studies included. When choosing a quantitative study such as a questionnaire with a large sample, and analyzing categories or variables, the verification bias has a greater chance of not being corrected and affecting the results due to the distance between respondents and the researcher (Flyvbjerg, 2001). Also, when samples are large there are fewer opportunities to revise the data (ibid).

Assuming the researchers goal is to learn and understand the studied phenomena, advanced and expert learning occur when researchers place themselves in the field within the context being studied, which is easier done within case studies and qualitative methods (Flyvbjerg, 2006). Flyvbjerg therefore conclude that case studies contains no more bias towards verification than other methods, but rather greater bias towards falsification of predetermined ideas.

The choosing of a case is of outmost importance when generalizing. Critics to case studies mean that natural science need large samples in order to generalize, although this is not always the case. When Galileo showed that a feather falls with the same speed as a lead coin in a vacuum tube, science embraced his gravitational theory. A carefully chosen case can be valid for a large range of cases, and random and large samples are not always the best way of conducting research. However, generalization is not the ultimate goal of research, it is rather to create knowledge. (Flyvbjerg, 2001).

Since extreme cases were chose, the results in stage 2 do not represent all of the public actors in the domain. Instead of generalizing, the intention was rather to illustrate the pioneering work of these public clients regarding timber building, and to assess the strength and impact of these timber building niches. Regarding researching stage 1, where the national context is framed using MLP, the results can be considered valid within Sweden.

3.5.2 Validity and reliability

The accuracy of an interpretation is often termed internal validity in the method literature (Denscombe, 2007; Silverman, 2005). When the researcher shows that the observations gathered are assessed and presented in reliable way, this is termed reliability (ibid). The techniques used in this thesis to ensure the validity of the gathered data involved multiple methods. Multiple methods can enhance the validity when the results converge and observations verify and validate each other (Bryman, 2011). This is also known as triangulation (Gillham, 2010).

In order to enhance validity of the data further, purposive sampling and snowballing sampling were used both when selecting cases and selection of respondents. The cases chosen are thereby valid in terms of pioneering cases and knowledgeable respondents. Extreme or pioneering cases are also especially good illustration of change and often possess a more critical view and deeper experience of barriers and how to overcome them (Flyvbjerg, 2006; Rogers, 2003). Moreover, the respondents were involved in local and national timber development and had significant experience of the studied phenomena. Qualified respondents adds to the validity in qualitative studies (Kvale & Brinkmann, 2014). A checklist of performed actions in order to ensure validity and reliability of this thesis is presented below.

3.5.2.1 Checklists of validity and reliability

Three main actions add up the validity in this thesis:

1. Multiple methods (literature survey, web survey, interviews)
2. Multiple data sources for each of the cases as well as the national regime (triangulation)
3. Purposive sampling of the extreme cases and key respondents

Moreover, reliability in the gathered observations is demonstrated by the use of:

1. Digital tape recorders to accurately capture respondent's views;
2. Transcribed interviews
3. Reviewed results by the respondents
4. Quoting that encourage own interpretations of the respondents answers
5. Parallel referencing through multiple sources.

4 Results and analysis – Stage 1

Stage 1 of the results is concerned with research aim 1 - Assess and reframe the literature about the Swedish construction sector, focusing on timber based building, from a MLP perspective. The main methodology has been a literature study of secondary data. The paradigmatic case presented in the end is an exception, drawing on primary data obtained through a semi-structured interview. The first stage concerns the socio-technical regime and the socio-technical landscape. Later, in Stage 2, local timber building niches are dealt with in depth in three extreme cases.

4.1 The socio-technical regime

4.1.1 Introduction

The construction sector is known for its conservatism and low rate of innovation (Roos, Woxblom, & Mccluskey, 2010; SOU, 2013; Tykkä et al., 2010; Winch, 1998). Framing the sector from the MLP perspective allows for illustration and analysis of these characteristic from multiple dimensions.

The notion 'the socio-technical regime' refers to the deep structural rules that account for stability in the socio-technical system. It is the 'rules of the game', the 'rule of thumb'. This contributes to stability in the system by guiding and coordinating the actor's perceptions and actions. Key elements include *industry, technology, policy, science, markets, user preferences and culture* and actors reside within each of these elements, governed by the rules of the regime (see 2.2.4 for details).

Onsite project-oriented building with concrete cast or prefabricated frames is the mainstream way of constructing multi-storey residential and industry/office buildings in Sweden (Bengtson, 2003; Brege et al., 2014; Hedgren & Stehn, 2013; Tykkä et al., 2010; Winch, 1998). The market share for this construction system is about 90 % (Andersson, 2014), although the absolute market share of concrete building vs timber building is of minor relevance for this assessment. More importantly, construction processes circles around onsite concrete building, which is mainstream in Sweden. Accordingly, the onsite concrete building in Sweden constitutes a socio-technical regime.

Actors within the regime element *industry* involve users, clients, contractors, architects, structural engineers and suppliers (Sou, 2002). It is important to realize that the notion of a socio-technical regime not only involve the actors within the industry, but all actors within the elements *technology, policy, industry, culture, science and markets, and users* (see Figure 3). This concept helps to move away from the prevailing mindset in innovation studies that major manufacturers (contractors in construction) are the pivotal actors (Geels, 2012). Contractors are indeed important actors and power dynamics contribute to the stability in the regime, but there is also established practices by professionals, policy, shared beliefs and discourses and culture that stabilize the regime.

4.1.2 Industry actor constellations

The actor constellation within the industry element is characterized by a few dominating actors, with power shifted towards three of four major contractors (Sou, 2002; Statskontoret, 2009). The three biggest actors presently is PEAB, NCC and Skanska, with a turnover ranging from 37 to 31 billion SEK (Sveriges Byggindustrier, 2013). Forth actor is JM with a turnover around 10 billion SEK (ibid). These four actors construct the majority of the onsite multi-storey concrete buildings in Sweden (Tykkä et al., 2010)

The major firms are powerful actors within the regime that influence through their products offerings, marketing strategies and political lobbying. Furthermore, these large contractors are active on the national and the international market and are to a large extent vertical integrated upstream the supply chain, including materials such as asphalt, ballast and concrete (Sou, 2002; Statskontoret, 2009). There is also vertical integration downstream the supply chain, where land is bought and the contracting firms act as a short-term clients (ibid). Moreover the project-oriented concrete building systems have a low degree of process-thinking, where project stages are seen independent by the involved actors (Sard, 2005). This results in dysfunctional market where the demand from clients do not work as in incentive to lower prices, build efficient and with high quality (Statskontoret, 2009)

Within the industry element, there are also a vast number of small enterprises. About 8 percent of the total amount of firms in Sweden are active within the building and construction sector (Sveriges Byggindustrier, 2013). Nearly 90 percent of these had four employees or less (ibid).

The next section will take a detailed look at the developments of the onsite concrete construction from a historical point of view.

4.1.3 Historical development of the socio-technical regime

Concrete as a modern construction material was first introduced in Sweden 1863 when building the Helsingborg harbor pier (Bengtson, 2003). Most of the work was handicraft until the beginning of the 20th century when prefabricated elements (concrete bricks) was introduced (ibid). During this time period, concrete as a material for multi-storey building was unchallenged. Timber building higher than two stories was prohibited in Sweden from 1874-1994 (see section 4.2.1 below).

During the 1930s/40s the residential construction market was supported with Swedish governmental incentives. These incentives aimed to provide decent low cost households with functional design, thus living subventions for low-income households were introduced. Consequently, demand increased for residential housing and the large construction actors (described above) entered the residential market. These construction companies, such as Skanska, were financial strong due to other business areas such as railroads, roads and bridges. (Bengtson, 2003; Boverket, 2002).

When entering the residential market, firms invested heavily in machinery such as cranes and gravity-operated elevators (Bengtson, 2003). In the 1950s, increased salaries and lack of labor encouraged more prefabrication of concrete elements. Further investment in transportation and production of heavy elements required a stable demand from clients, and also financial support. This prompted the Swedish government to set the 1965 goal of building one million new low cost apartments in ten years (Boverket, 2002). Capital was provided with governmental supported loans as long as buildings were uniform. Prefabricated concrete elements were used for framing and façade. Eventually, the production cost decreased and the goal of one million new low cost apartments was reached, but the quality of the buildings was much questioned afterwards (ibid).

As a conclusion, large contracting actors entered the multi-storey residential building market in the middle of the 20ths. These actors expanded through vertical integration downstream. Concrete building systems developed and governmental incentives sustained demand and encouraged large investments in infrastructure

4.1.4 Sunk investments

As concluded in the historical outlook, major construction actors have over the years invested in concrete dependent infrastructure. In order to maintain productivity, new investments are needed to replace old machinery (Mahapatra & Gustavsson, 2008). Moreover, the large actors are vertical integrated upstream the value chain, adding to the investments related to concrete usage (Sou, 2002; Statskontoret, 2009). Hence, sunk investments in infrastructure contribute to lock-in towards onsite concrete building systems and thus stability in the regime.

4.1.5 Culture

Shared beliefs and discourses also contribute to stability in the regime. Professionals have naturally been influenced by concrete constructions since this has been the principal building system. Likewise, education and experience of construction have been dominated by the regime rules, or the mainstream way of doing things, thus leading to thinking inside the box.

Shared beliefs among actors regarding technical issues with new construction systems such as timber building still persist in the construction sector (Riala & Ilola, 2014). This mainly regard inaccurate perceptions about acoustics, maintenance, and shorter life cycles for timber building systems (ibid). Some earlier research also emphasize the conservative perceptions lingering with architects and structural engineers, where timber is perceived as an interesting material but with negative aspects regarding decay, instability and acoustics (Hemström, Mahapatra, & Gustavsson, 2011; Roos et al., 2010).

Regarding cultural developments within the regime, normative rules and expectations exist (Mahapatra & Gustavsson, 2008). Informal, hard knit networks are common, with strong relationships between suppliers and contractors leading to material choices that suits these relationships (ibid). These informal networks also constitute an entry barrier to new actors (Statskontoret, 2009) and thus contribute to the stability in the regime.

4.1.6 Power relations

Beside investments, shared discourses and culture there is significant power relations to consider within the regime. According to Winch (1998) principal contractors and principal architects/engineers are ‘system integrators’ with significant power over material choosing and innovativeness. In Sweden, findings indicate that principal architects and engineers in general do not perceive themselves as influential in the material choosing (Roos et al., 2010), leaving the principal contractors in a powerful position. Traditionally main contracting have been used by clients and entrepreneurs in Sweden, placing much of the power at the contracting firm (SOU, 2013; Winch, 1998). Thus, incentives from clients regarding lower costs and innovation are often lost. Knowledge regarding building processes are also lost among clients (SOU, 2013). However, there are ways of altering this power relationship and increasing the knowledge among clients. As presented in the Falun case, section 5.4, alternative ways of procuring may shift power back to the clients.

4.1.7 Policy

The regime have been influenced of some recent major policy changes. This is examined in more detail under landscape developments, section 4.2. In general, construction industries are considered as a national concern. Therefore specific national building regulations have been specified within countries, even within the Nordic areas (Boverket & von Platen, 2009). This affect the regime and niche actors that aim for a larger market than the national scene.

Some building codes are harmonized in EU, but in practice building regulations differ on a national level, and even regionally or locally (ibid). For example, different regulation exist for size and dimensions of specific rooms, stairs, energy, structural design and moisture protection in bathrooms (Pousette & Gustafsson, 2008). The result is trade barriers for actors concerned with exporting buildings, since the local regulations favor onsite project specific building methods. Industrial building methods for multi-storey houses are limited to national regulations, which is a problem when prefabricating and using 'mass customization techniques'. These trade barriers thus contribute to the stability in the regime, since onsite project oriented building methods are encouraged.

In regulations dealing with public procurement, there is a widespread recognition from clients that the Swedish law is complex, inflexible and also unclear (SOU, 2013). It is not known how far clients can make social and environmental demands, or whether special choices and needs can be considered. Consequently, small clients perceive innovation in public procurement as challenging and risky (ibid).

4.1.8 Conclusion

Building with 'conventional' methods still has a dominant market share, especially when building flats and normal sized office and industry buildings. Onsite, concrete building methods is mainstream and the 'rules of the game'. Accordingly, from the MLP theoretical perspective, the conclusion is that the prevailing Swedish onsite concrete building system constitutes a socio-technical regime.

The concrete regime has developed unchallenged of other materials and supported by governmental incentives. Sunk investments, shared beliefs and discourses, traditional culture, power relations and policy contribute to lock in and path dependency within the construction regime. Accordingly, regime actors are prone to incremental change and resist radical change.

Examples of lock-in within the concrete regime are a few dominant industry actors; sunk investment in machineries across the supply chain, specific competence regarding concrete and steel building, traditional culture, different national legal frameworks and uncertainties regarding public procurement. Thus, innovation tends to be incremental and along predictable trajectories.

The next section will analyze the socio-technical landscape. The landscape is the wider context, that influence both niches the regime. It is considered the most stable level in MLP.

4.2 Socio-technical landscape development

There are some significant landscape developments that have affected the timber building niche and the current regime. According to the theoretical frame of reference, regimes faces both stabilizing and destabilizing landscape pressures. Landscape change is a broad source of pressure at the regime level, which can create opportunities for niche developments, or make the regime realign in response of this pressure. Typically, when the socio-technical landscape changes, the regime is slow to adapt due to inertia (lock in characteristics and path dependency). This inertia creates a window of opportunity where niches can advance.

4.2.1 Functional legislation for multi-storey buildings

During the 19th century Sweden was tormented by several big fires in the cities. The dense timber housing in urban areas was pointed out as a national risk due to fire hazards. Therefore, in 1874 Swedish policymakers adopted legislation that forbid timber framed housing higher

than two stories. (*Byggnadsstadga för rikets städer*, 1874). These old building codes lasted for more than a century and affected the development of the construction sector during this period (further described in section 4.1.3 above). When Sweden became a member of European Union, these building codes were replaced 1994 by functional based codes used within EU (Tykkä et al., 2010). These new functional codes referred to certain functionalities, such as fire resistance during a certain time period, rather than specific material rulings (ibid). The regulatory change regarding functional building codes can be seen as a landscape development putting pressure on the regime. Previous this change (before 1994), the onsite concrete regime was protected from other material competition.

The regulatory change created a 'crack' in the regime, a window of opportunity that awoke keen interest from the sawmilling industry. Sawmill actors saw an opportunity of increasing the amount of timber used in construction (Timwood, 2004). Accordingly, new actors entered the socio-technical system introducing timber building systems. This can be framed as a new niche (with practices deviating from the regime), advancing as a direct result of landscape pressures. The regulatory change in building codes was a pre-requisite for this advancement (Tykkä et al., 2010).

4.2.2 Environmental sustainability

Another major landscape pressure is the environmental sustainability forces. Sustainability within the construction domain has traditionally circulated around post-production energy consumption since this was perceived to be the major source of environmental impact (European Commission, 2011a). However, new findings emphasize that buildings have significant impact on the environment both in terms of material usage and post-production energy consumption (European Commission, 2014; Sveriges Byggindustrier & IVA, 2014).

The material phase has been found to impact the environment more than previously believed, and all together the building processes in Sweden release carbon dioxide in the same level as all the passenger cars in the country (ibid). Furthermore, research indicate that timber as a material has carbon emission advantages compared to concrete when analyzed with life-cycle assessments (LCA) (Dodoo, Gustavsson, & Sathre, 2014; Sathre & Gustavsson, 2009a, 2009b). This is also recognized by European Commission (European Commission, 2011b).

Concrete building methods has realigned somewhat as a response of environmental pressures. Present concrete construction tend to focus on post production energy efficiency concrete/steel. German concept Passivhaus is one example of a concrete building system specialized in energy-efficient buildings (ibid). However, sustainable alternatives concerned with natural materials have been slow to get underway (Tykkä et al., 2010). As with the case of Passivhaus, the environmental landscape pressures has created a window of opportunity for new actors specializing in the sustainable niche. Green building are one of those niches, incorporating actors concerned with reducing the environmental impact of constructions (ONeill & Gibbs, 2013).

It is noteworthy that the green building niche also incorporates actors concerned with natural materials. Thus, timber building is part of a wider green building niche. However there are other advantages with industrial building with timber besides environmental aspects, such as the potential of decreasing building costs (Brege et al., 2014; Gustafsson et al., 2012; Hedgren & Stehn, 2013; Roos et al., 2010; Tykkä et al., 2010). The next section details the rising building costs and the pressure this put on niches and the socio-technical regime.

4.2.3 Rising building costs and increasing housing needs in Sweden

Sweden has the highest urbanization rate amongst EU-members, and Stockholm is one of the fasted growing cities within the European union (Skanska, 2014; TT, 2012; United Nations, 2014). The national market is currently facing a long term shortage of housing, mainly because the demand for attractive housing has increased rapidly during the last decade. The construction of new buildings has been unable to follow this increase (Boverket, 2012).

Demographics have a high impact on demand for multi-storey residential housing, and therefore the urbanization rate and population growth are important drivers on the demand side (Boverket, 2014). Consequently there is a strong demand for more and cheaper housing in Sweden. Prices of flats have more than doubled since 2005 and building costs have increased by 20 percent between 2007 and 2013 according to the Swedish building price index, BPI (SCB, 2013). Meanwhile, Sweden has the highest construction prices in EU, exceeded only by Norway, and 40 percent higher construction costs compared to Finland (Eurostat, 2014).

The high construction costs in Sweden have initiated some research regarding why the construction costs are disproportionately high, although the findings are scarce. The direct cause of the high production costs is a broad subject, and it is important to note that the high production costs are measured in market prices, i.e. that both supply and demand affect the 'building costs' (Boverket, 2014). Nonetheless, there is an uncertainty among clients of the actual construction cost. Uncertainties flourish about cost-effectiveness amongst conventional building methods, and incentives for increasing the competition is usually the chosen path when trying to lower the construction costs (Skellefteå Kommun & Trästad, 2015).

There is also a widespread recognition that the long term shortage of housing in Sweden is problematic. The high market prices has led to a development where condominiums been prioritized before rental apartments, since these houses generate a 75-100 percent higher market price (Boverket & von Platen, 2009). Moreover the willingness to pay for expensive flats is concentrated to the most central part of the cities. This has resulted in a specific shortage of low-middle income housing in the peripheral urban areas (Boverket & Netzell, 2014).

The allocation of newly built multi-storey houses towards high-end buildings in central areas have open up for niche actors to explore specific segments such as low cost housing. Also, there is strong demand for residential buildings in urban areas, where adding floors on existing buildings is one option instead of new buildings. Accordingly, one window of opportunity for timber building has been low cost housing such as student housing or market segments where light weight material is favorable.

4.2.4 Regime realignment

Landscape pressures do not automatically make radical transitions happen, where niches take over and a new regime is formed. Landscape pressures usually influence the internal dynamics of the regime, resulting in internal realignment. Some identified regime responses to landscape pressures are illustrated below. It's important to remember that radical deep structural transitions seldom happen, and take time. Section 2.3.2 elaborate on the theoretical transitions pathways in MLP, and section 6.3 discuss timber building transition pathways with regards to this theory.

4.2.4.1 BoKlok – timber building by conventional actor

An identified example of regime realignment involve low cost building. Exploring low cost buildings, regime actor Skanska and furniture retailer IKEA started a joint venture called BoKlok. BoKlok mass produce timber framed terrace houses and up to four storey residential houses (BoKlok, 2015). These products are locked in the design phase, so only one specific design is offered to clients (ibid). This separates the concept from other actors within the timber niche, since the timber niche generally provide timber framed solutions with varying flexibly in the design phase.

4.2.4.2 Public procurement – framework agreement from SABO

Another regime realignment originating from the policy element. Pressures from rising building costs has led to a public procurement frame agreement regarding multi-storey residential housing. The actor behind this agreement is SABO – the Swedish Association of Public Housing Companies, which is an organization consisting of all the municipal public housing companies in Sweden (SABO, 2014a).

To achieve this framework agreement, SABO initiated a competition called SABO KomboHus. Construction companies were challenged to offer a turn-key multi-storey residential model house with a fixed price (SABO, 2015). This proved to be a successful approach towards lowering the building price, and a 5-8 story frame agreement is available until 2017. Actors that won this competition were Skanska, NCC and Lindbäcks Bygg AB. (SABO, 2015), where Lindbäcks Bygg AB offer a timber framed model house. Moreover a similar agreement is available for flats less than 35 m2 with contractors PEAB, JSB and Lindbäcks Bygg AB (SABO, 2014b). Skanska, PEAB, JSB and NCC uses conventional building methods and Lindbäcks Bygg AB is an industrial builder using timber as frame material.

The next section will elaborate on landscape pressures using the municipality of Hammarö as a paradigmatic case.

4.2.5 Client outlook – Hammarö municipality

Landscape pressures affect both actors within niches and socio-technical regimes. Actors within the socio-technical regime respond to landscape pressures with incremental change and path dependent actions. As a paradigmatic case, this thesis include Hammarö municipality. Hammarö is located in the Province Värmland and inhabits 15 000 people (Hammarö Kommun, 2015). The municipality is one of the smallest in Sweden, however, they cope with many of the contemporary landscape pressures described above.

In 2013, a six-storey building with 30 flats adapted for elderly people was finished in Hammarö municipality (Hammarö Kommun, 2013). Contracting was made through strategic partnering (Barthelson, 2015), where the client decides to work with a defined set of suppliers over a number of projects (Manchester Business School, 2009; NCC, 2015). The perceived benefits of choosing strategic partnering with Skanska was in this case better control over costs and a higher degree of involvement from the client (Barthelson, 2015).

This type is public procurement contracting can be seen as a realignment within the policy and industry dimension of the regime, since it is an incremental change within the regime. This type of procurement do not radically deviate from existing practices and cannot be considered a niche practice.

In order to cope with the rising building costs, clients look for new ways of conduction business within the sector, and strategic partnering is one of the incremental innovations offered by regime actors. For Hammarö, this resulted in marginally lower costs and increased influence over the building processes, thus higher control over expected and unexpected costs (Barthelson, 2015)

The municipality of Hammarö is also affected by demographic changes where the population increases. Consequently the municipality experience a shortage of flats and there is need to produce new residential housing. The local public housing company is currently considering SABO:s frame agreement regarding KomboHus (see 4.2.4.2 above). Compared to the elderly care project where strategic partnering where used, SABO:s framework agreement solutions are perceived much cheaper, even in consideration of special solutions for elderly people (Barthelson, 2015).

One of the suppliers in SABO:S framework agreement (although not firsthand choice in the agreement) is industrial timber building actor Lindbäcks Bygg AB (SABO, 2015). Since all of the options in SABO:s framework agreement are considered, the public housing company in Hammarö may build with timber building methods in the future. However, environmental goals have not been prioritized previously in the municipality, and low cost is the main focus of the public housing company (Barthelson, 2015). It is therefore unlikely that the decision criteria regarding supplier within the framework agreement are based on environmental benefits.

Moreover, the public housing company in Hammarö do perceive themselves as a driving force for innovations. This is due to the high risk associated with new thinking and innovations, although when market solutions exist that lower the construction costs this is a favorable choice for the public housing client (ibid).

As a concluding remark, Hammarö is actively participating in networking activities. Learnings from other regime and niche actors within these networks are adopted in the municipality. This outlook aims at illustrating how Hammarö municipality (as a client) uses incremental innovations from the regime in order to cope with landscape pressures. Strategic partnering and SABO: s framework agreement are examples of regime realignments within the policy element. However, these changes are incremental since they do not deviate much from existing practices, and onsite concrete construction methods are the mainstream building techniques. These changes are not deep structural, although for Hammarö it has resulted in improvements at the local scene. Thus, measurements used in Hammarö are not sufficient for calling the municipality a timber building niche, and therefore Hammarö represent a paradigmatic case in this thesis.

Next section will describe the national timber building construction niche, and its main industry actors. Thereafter three local extreme cases of timber building are presented, see section 5.

4.3 The national timber building niche

In terms of the introduction of multi-storey timber building solutions on the Swedish market (introduced when legislation changed 1994), timber building can be considered a radical innovation (Tykkä et al., 2010). In MLP, niches are practices or technologies that deviate from the existing regime (see 2.2.3). Timber building solutions deviate substantially from the regime, since the material can be used in new processes such as industrial building and also

draw upon environmental advantages (see intro 1.2). Accordingly timber building can be regarded as a niche using the MLP framework.

Regarding industry element within the timber niche, there are some established national actors in Sweden. In volume element production, major actors are Lindbäcks, Moelven, and Setra. These companies have taken up the role as main contractors and uses design-build contracts, i.e. they are timber system suppliers with turnkey offerings (Brege et al., 2014). Another well-known actor in Sweden providing prefabricated timber solutions is Martinsons, or its subsidiary Martinsons Building System AB. This company manufactures solid wood floor/wall elements (CLT) combined with glulam (Martinsons, 2015a). A fifth actor is Masonite who provides an open building system. This system consist various timber I-beams prefabricated by Masonite, and separately prefabricated floor/wall elements. These elements are made by a project specific manufacturer or through long term agreements. Lastly design and assembly instructions are offered (Masonite, 2015). These timber building actors and their business models are described in more detail in the Växjö Case, see section 5.1.5.2.

4.4 Conclusions in stage 1 and point of departure

The aim in stage 1 has been to assess and reframe the literature about the Swedish construction sector from a MLP perspective, with focus on timber building methods. Using MLP, the socio-technical regime and the external socio-technical landscape have been illustrated and assessed. Some multi-level interactions are considered with focus on regime realignment. Based on this broad application, I conclude the following:

1) Onsite concrete building constitute a socio-technical regime.
2) Lock-in is due to sunk investments across the supply chain and specific competencies, different national legal frameworks, traditional culture and a few dominant industry actors.
3) The concrete regime is still dominant and stable, although landscape pressures the regime which creates windows of opportunities
4) Landscape development pressures include functional building codes (1994 legalization change), environmental demands, increasing housing need and alarming production costs.
5) Some regime realignment include energy-efficient building, framework agreements (SABO) and BoKlok concept.
6) Timber building systems constitute a niche on the market.

This sets the point of departure for the research stage 2: three cases of local timber building developments. Public housing companies represent 20 percent of the total housing stock (SABO, 2014a) and local government in Sweden is strong. Thus the three cases chosen constitute municipalities known timber building developments (for delimitations see 1.5.1).

The overarching aim in this thesis is to investigate the transition towards timber based building in Sweden. Transition pathway can vary (see theory section 2.3) but generally one pathway can be illustrated: (Geels, 2011)

1. Niches build up internal momentum, i.e strength for breaking through the regime.
2. Changes at the landscape level create pressure on the regime.
3. Destabilization in the regime creates a window of opportunity where niche innovations can advance and eventually reconfigure the old regime.

Stage 2 proposes to investigate the local timber niche developments and their internal momentum. MLP theory present three categories for niche developments (see also 2.2.3.1):

- Expectations or visions. Articulation of expectations aim to attract investors for external funding, and also provide strategic guidance to innovation activities.
- Social networks. Building new networks and involving more actors expands the social and the resource base of niche novelties.
- Learning and articulation processes. Valuable lessons are being learned of niche actors regarding technical design, market demand, user preferences, and business models. Also experience regarding infrastructure requirements, organizational challenges and policy.

Niche development constitute the structure of the results in stage 2. Moreover, the internal niche momentum builds upon how far the niche has come regarding the three processes above. Thus each case ends with an assessment of the niche momentum (see theory section 2.2.3.2).

5 Results and analysis stage 2

The objectives for stage 2 is to assess and frame timber based building niches, their origin and developments using MLP. In the end of each case, the timber building niche momentum is analyzed.

5.1 Case 1 - Växjö municipality

5.1.1 Introduction to Växjö municipality

Växjö municipality is located in Province Småland[1], a region known for its forestry, particularly single family housing, furniture industry and an abundance of forest resources (Bergström & Johansson, 2010; Eriksson, 2013). Large actors such as Södra and sawmill company VIDA has located their headquarters in the region and well know furniture retail company IKEA originate here (Ikea, 2015; Södra, 2013; VIDA, 2015). The region is known for its entrepreneurship and richness of SME:s and some important industries besides forest related businesses are glass manufacturing and tourism (Lagundžija, 2014).

Växjö is a University town and seat of the municipal administration (Linnaeus University, 2015). The municipality currently has 86 000 inhabitants making it the biggest municipality in Kronoberg county and 23th of the total 270 municipalities in Sweden (SCB, 2014a). The municipality is affected by landscape demographic pressures due to its University status and housing demand increases (Boverket, 2012). Moreover, Växjö is one of the earliest adopters in Sweden regarding multi-storey timber building (Bengtson, 2003).

The following structure relates to the theory section regarding niche development. Each subsection begins with a brief summary of the theory and ends with a concluding analysis.

5.1.2 Processes for establishing expectations and visions

Processes for establishing expectations and visions include articulation and adjustment of expectations or visions. This provide guidance in the innovation activities and attract attention from external actors.

5.1.2.1 Växjö's experiences of demonstration projects [1992-2002]

The municipality of Växjö were an early adopter of building multi-storey residential timber housing (Bengtson, 2003). Projects were underway even before the change of legislation in 1994 (Andrén, 2015). To allow the construction of these early multi-storey timber houses, a special permission from Swedish National Board of Housing, Building, and Planning[2] was acquired. With this special permission in place, two sets of timber framed flats were built by Växjö's municipal housing company in 1992, each house three stories high.

The learnings from this project tended to be technical and internal to the project members (Bengtson, 2003). Subsequently other residential projects were undertaken. These had loose ambitions about industrial production, and as a consequence the houses were locally offsite produced in prefabricated elements and transported to site with trucks (Växjö Kommun, 2012).

[1] Provinces in Sweden hold no administrative power
[2] Boverket

Some years later, in the middle of the 1990s, the forest owner's association Södra[3] completed phase 1 in Wälludden, which consisted of two multi-storey residential wooden houses, four and five stories high. It was constructed by Skanska with elements fabricated in a temporary onsite factory (Gustafsson et al., 2012; Tina Wik Arkitekter, 2015). The purpose of this projects was to initiate wood as a construction material in the area of multi-storey residential buildings (Tina Wik Arkitekter, 2015) and the construction methods were inspired from overseas (Växjö Kommun, 2012).

These latter projects were the beginning of a new 'industrial building' orientation for Växjö municipality and Södra:

"…these projects, ours and Södra's, made for a profiling question if one is generous. One should not exaggerate, but one could sense a profiling question … For the business through Södra and through the municipality through its municipal companies. It all started to come to life. (Andrén, 2015)*"*[4]

The concept of industrial building is to produce housing in an offsite factory, with the intention of improving quality and reduce costs (Timwood, 2004). The European forestry sector consider industrialized building to be a mechanism for increasing the use of timber in construction (European Commission, 2011a). Timber has advantages in industrialized building, where light weigh enables transportation of prefabricated elements (Tykkä et al., 2010). In the local case of Växjö, early visions involved these benefits.

The interest for building with wood increased over the years and in 2002 Videum, a municipal company that owned university buildings in Växjö, considered and adopted a position of increasing the use of timber in large constructions (Andrén, 2015)

5.1.3 Växjö's articulation of expectations and visions

In 2004 a national political interest of promoting large timber houses emerged. This resulted in a nationwide strategy for increasing the construction of multi-storey timber houses, adopted by the Swedish government (Näringsdepartementet, 2004). The vision was to make timber an evident material alternative when construction large building, and increase the wooden framed market share to 30 percent during a period of 10-15 years (Sveriges Riksdag, 2008).

This national strategy raised awareness of the matter in a wider sense, but there were no financial support at this time (Andrén, 2015). Local persons in Växjö were involved in the national timber building strategy, and in 2005 the municipality of Växjö was ready to adopt its own timber building strategy (ibid). With unanimity, in 2005, the city council adopted in a local strategy for building with wood (Växjö Kommun, 2005).

This strategy has since been matter of strong consensus in the region (Andrén, 2015). In 2013 the city council of Växjö adopted a revised strategy with new visions and goals, where the following visions are articulated (Växjö Kommun, 2013b):

- The municipality are to be independent from fossil fuels – stop using fossil fuels
- Use energy efficiently
- Make the region Småland the leading timber region in Europe by 2020
- 25 % of all new construction are timber based 2015

[3] Södra is a Forest owners association that produces wide variety of forestry products including construction products

[4] The quotations are translated from Swedish

- 50 % of all new construction are timber based 2020 (ibid).

These local timber building strategies can be considered as articulation of visions and expectations within the local timber building niche. Section 5.2 elaborates on the niche momentum that is gained from these local measurements. This momentum can be seen as the strength of the local niche, where niche actors hope that the innovation is used in the regime, or even replace it.

5.1.3.1 Summary of articulation of visions and expectations

A local timber building strategy was adopted in 2005 as a consequence of the national timber building strategy. The early visions were framed technically in terms of industrialized building. In 2013 a new more precise strategy was adopted in the region. Here visions are framed more broadly in terms of climate change concerns. Lastly, it's noteworthy that this shift in vision setting has taken two decades.

In this next section, the networking processes are described and how these actions have enabled the articulation of these visions.

5.1.4 Processes for establishing and running social networks

The theory section emphasize the processes of establishing and running social networks. Network processes include establishing social networks and the enrollment of more actors, which expands the social and resource base of the niche-innovation.

Enrollment of more actors includes investors in the niche. In these cases, main investors considered are the public clients. However, in the general MLP framework, investors include all actors that invest in technology. Within the construction sector, this may be private companies or suppliers of timber framed components and building services.

5.1.4.1 Triple-helix and local political courage

As mentioned earlier, in 2002 the publically owned real-estate company Videum adopted a strategy for building with timber (Andrén, 2015). The main reason for this was because the University of Växjö (now Linnaeus University) started to engage in timber building questions with an impending faculty and professors specialized in wood (ibid). This collaboration between the university, public sector and the business sector is commonly referred to as *Triple Helix* (Morén & Hård af Seferstad, 2010) which in its essence is the dynamic collaboration of actors from different contexts (Wilson, 2012). In the municipality of Växjö, this triple helix environment is perceived to be important for the timber development in Växjö region:

"Even in the beginning of 2000, a triple helix environment existed and has since been active during a period of ten to fifteen years. I.e. the academy, business and the public sector all together undertook these matters. If this happens, which of course is easy for me to say, if you do it this way, the whole thing grows."(Andrén, 2015)

Amongst these three contexts, the political dimension with the commitment of local politicians was perceived as very important:

"…what is it the essence in all this? It is the presence of political courage, i.e. the politicians have the courage to decide a direction not only for schools, elderly care, taxes or whatever it may be, but also have the courage to say that we are going to put some effort in increasing building with wood. And when they get the question why -it is because of the climate, the energy, shorter construction time and a sea of other arguments." (Andrén, 2015)

The theory emphasize the enrollment of actors within the niche networks. What is commonly referred to as triple helix, is in the MLP framework referred to as the elements in the socio-technical regime, namely policy, science and industry (public clients in this case).

Besides the triple helix environment, the municipality locally engage a group called CBBT, Centre for Building and Living with Timber[5]. In addition to public actors from Växjö municipality, CBBT include investors and researchers such as University of Linné, Södra and SP Trätek[6]. This group initiate and secure finance for R&D projects related to timber building and use (CBBT, 2015).

In short, the municipality of Växjö is investing in timber building through its publicly owned housing companies. The timber building network includes local policy actors, industry actors in form of public clients and science actors from the university. Local networking also include the group CBBT. This next subsection will consider another actor within the local context; the suppliers of timber framed components and solutions, commonly referred to as the local entrepreneurship within timber building.

5.1.4.2 Local entrepreneurship

Local entrepreneurs invest in the capacity of supplying timber framed houses or components. At the national level, the suppliers of timber components are scarce and concentrated to a few national actors with a low portion of small and medium enterprises (Falu Kommun & Trästad, 2014; Skellefteå Kommun & Trästad, 2015) However, at the local level in Växjö there is a fairly large number of small and medium enterprises that has adapted for multi-storey timber constructions (Andrén, 2015):

"Here everybody knows it already. We had a tendering for a large house at the university and I don't think we even wrote wood in the contract documents, but we got six offerings on the tender – all of them constructions with wooden frames. "(ibid)

As mentioned in the case introduction, Växjö area with its surrounding area is known for its entrepreneurship and forest products. This may have eased the adoption of multi-storey timber building for SME:s in the area, or maybe not. The exact reasons is outside the scope of this thesis. As for the purpose of this thesis, it is sufficient to conclude that the adaption of local entrepreneurship strengthen the timber building in Växjö.

5.1.4.3 National networking

The vision for industrialized building is inspired by manufacturing industries, particularly the car industry, where processes eliminate waste and ensure quality (Egan, 1998; Näringsdepartementet, 2004). When asked about the importance of networking, the respondent compares the question with how large successful companies such as Toyota or Airbus construct their products with the help of networks, arguing for the importance of networking (Andrén, 2015).

Industrial builder Martinsons (more detailed explained in section 5.1.5.2) uses a large business network in order to reach out to architects, public and private clients, and large contractors (Brege et al., 2014). More specifically the networking is used for gaining influence in the design phase which is important for efficient use of prefabricated building systems (ibid).

[5] Authors translation

[6] SP Wood Technology, research organization specialized in applied science. One of four offices is located at Campus in Växjö

However the interviewee suggested there are no large networks for building with timber, although there are a few national and international networks Växjö participate in (Andrén, 2015).

In the Nordic geography, Växjö has been a driving force in Nordic Wooden Cities for ten years (Andrén, 2015). Nordic Wooden Cities is a collaboration comprised mainly of Nordic municipalities with the addition of some research organizations and a few actors within the timber building industry (Nordiska trästäder, 2015b). The purpose of this collaboration is to ensure broad support of timber construction, formulate best practice, strengthen the bonds between the public and private actors, and create new demonstration projects (Nordiska trästäder, 2015a). Regarding resources, this network is now at a stage where the economy and the amount of actors permit joint projects (Andrén, 2015). Such joints projects can grow the investor market in timber housing.

The development within the network Nordic Wooden Cities was exemplified by the following quote:

"We have come to a point where we start to see that the Nordic networks can start projects together because we are so many members and have a sufficient economy. Why? Because the Nordic countries are a huge geography, a gigantic geography with very few people and very few resources. This together makes networking suitable for a relatively new instrument such as large timber constructions. To do it together, the academy, businesses, corporations, architects, institutions etc. and sharing experiences is what can take this forward."(Andrén, 2015)

The respondent understands that growing the networks are important (as does the theory, see 2.2.3.1). At one point the respondent speculates in what would happen if an actor such as Södra would commit and invest in timber framed buildings, arguing that this would take it to a new level. The commitment of large and powerful actors is emphasized in the literature as well, which is further discussed in niche momentum in the end of this case.

Another recent development is the adoption of a declaration of intent with the municipality of Skellefteå, stating that the two municipalities shall work together in order to initiate a new governmental program benefitting the national timber building (Forsman & Andersson, 2015; Växjö Kommun, 2013a).

Moreover the Swedish government has showed interest in timber building, most recently with the national forestry program "Skogsriket", scheduled to start during 2015. This program is currently underway, with the intent to develop the forestry sector in Sweden including increasing the construction of multi-storey timber (Erlandsson & Yngwe, 2014). However the impact of this national program is already questioned elsewhere (Nilsson, 2015).

5.1.4.4 Summary of networking activities in Växjö

The networking between the university, business and public sector has historically been important for timber building in Växjö. This so called triple-helix environment is essentially networking between three actors from different contexts. The commitment of the political actors, referred to as "political courage" by the respondent, was perceived very important, suggesting this is an important actor in facilitating timber development at the local scene.

Local networking includes local entrepreneurship. Växjö has a fairly large number of small and medium enterprises that has taken up the timber building either supplying components or turnkey houses. At the national networking level, such as the formal timber building network Nordic Wooden Cities, actors start to utilize the joint resources in joint niche-innovation

activities. According to the theory, networking adds social and economic resources to the innovation. Apart from increased resources, valuable lessons can be learned from other actors in the networks. This next section will address lessons learned within the timber building niche.

5.1.5 Learning and articulation processes on various dimensions

Learning and articulation processes refer to valuable lessons are being learned of niche actors regarding technical design, market demand, user preferences, and business models. It may also include experience regarding infrastructure requirements, organizational challenges and policy.

As stated in the introduction of this case, Växjö municipality can be considered an early adopter of timber building (Bengtson, 2003). Buildings were underway even before the legislation change in 1994 (Växjö Kommun, 2012), providing the municipality plenty of learning opportunities from the various demonstration projects. The theoretical framework assesses that niches are often carried by experimental or demonstration projects, which allow actors to learn about innovations under real life circumstances. In the case of Växjö, the early demonstration projects allowed actors to learn about multi-storey timber constructions.

5.1.5.1 Technical aspects

According to the respondent, technical barriers traditionally related to multi-storey timber building have been resolved. Such barriers have traditionally been concerned with fire safety, acoustics:

"Yes I would say barriers have been overcome in all the technical aspects; fire, stabilizing constructions, wind, vibrations, acoustics and subsidence. Challenges that remain are increasing competition, more actors and the discussions about open and closed systems. But in technical aspects, Sweden has come very far."(Andrén, 2015)

Although the technical solutions exist, the interviewee explains that doubts still are being raised regarding technical issues:

"I have received 8 000 persons from 34 countries when showcasing our projects. There are still people that do not understand that this eight-story building is constructed out of timber. They cannot even imagine it since they have such a strong conception of what is possible and what is not possible."

Other studies also confirm that negative cultural beliefs about technical aspects within timber building persist (Hemström et al., 2011; Riala & Ilola, 2014; Tykkä et al., 2010). Beyond technical aspects, Växjö are looking for new dimensions such as maintenance or health and its correlation with timber structures. The interviewee explains how they can move on to softer values since the technicalities have been measured for a long time:

"We can look at aspects that today are hard to measure since we have completed 20.-30 projects since the 90ths and forward. We have measured and are still measuring what can be measured, acoustics, vibrations, subsidence etc… We have a 20 year old project now, Wälludden. Here Södra can see that there are very limited costs spent on the common areas in these residential areas, for example in stairwells. It's something about these surroundings, visual timber makes people careful and there is a respect for the material in a whole new way. Of course this is easy to say but what if one can make academic studies of it, of the things that are not measurable? That's coming up now, on several fronts." (Andrén, 2015)

It seems that the local measurements are moving away from the pure technicalities toward end-user preferences and maintenance costs. According to the theoretical frame of reference, the timber building niche develops when stable configurations align. During the two decades that Växjö has been present in the timber building niche, stable technical solutions have

developed. In the next subsection the local market demand and its drivers are examined further.

5.1.5.2 Market demand,

The general demand for innovation in the construction industry (and industrial building) is driven by several aspects such as increasing building costs (SCB, 2014b), increasing demand for sustainable buildings including the production phase, lack of labor since onsite production is labor intense business (Nord & Brege, 2013). At the local scene where the public companies in Växjö act as clients, the political dimension influence market demand by setting market share goals. My assessment is that the timber building strategy with its market share goals is one important driver for the local market demand.

Learnings regarding market demand are becoming increasingly clear to the local actors. This shows when the respondent was asked about problems with the traditional actors such as the steel/concrete actors:

"I have been doing this since the late 80s and I have never, and will not ever, talk down on other material. It is completely irrelevant since wood fully stands on its own legs. I mean, we are starting to see the results, it is not more expensive, the construction time is faster, the cost for the client is lower, and eventually the competition increases which affects cost of building. In the end, living costs will be affected and it will be cheaper for young or old citizens to rent these residences."(Andrén, 2015)

Economic arguments such as lowering the building costs and indirectly the cost of living, as well as developing the local SME and increasing the competition seems to be of local importance. My assessment is that these economic aspects are important drivers in promoting timber building and increasing the local demand for this type of building.

The respondent later adds that building with wood is an easy way of improving the issues of climate and energy as well. Lastly, flexibility is used as an argument for adopting timber framed solutions:

"We cannot afford to have a depreciation period of 60 years. We cannot afford, or have the energy, to rebuild. The quality must have the flexibility and survival so we can speak of 100 or 150 years. That's where timber has its place, with a flexibility that's totally different than other materials… our houses here are made of elements and blocks. In 100 years from now, you can simply disassemble the building. Or remake it into a daycare or whatever it may be. If you don't need it, disassemble and use it for energy, burn it. Or rebuild it where it stands, it is easy to find architectural flexibility in a simple material like timber. "

In short, the local demand in Växjö is influenced by politics in a higher grade than the national scene, since the local politicians set specific market share goals for timber building. Valuable lessons learned regarding market share includes arguments in favor of timber building, such as economic aspects, environmental friendliness and long term flexibility.

5.1.5.3 User preferences

Regarding preferences for the client, who are the owner and the administrator of the building, the respondent asserts that the client role must be improved and argues that the client's in general needs to learn how to articulate their actual needs.

"We have systems for following up and specifying what we want and do not want, but when it comes to timber related questions there is still an awful lot left to do. When we exercise public procurement there is contract specifications regarding electricity, ventilation and plumbing stacking three or four centimeters high, but not one page written about timber….Instead of just specifying a room with nine square meters, one should really specify what is needed. It puts pressure on us as clients. If one looks at the clients generally, it is the Stone Age in some

places. They want what they did yesterday without knowing what they really did, since they think it was good. But that is not enough. Especially not now." (Andrén, 2015)

The interviewee then adds that there is presently work going on in specifying the client needs:

"At the moment a fair amount of work is put into specifying what we really want when we use wood. How do we want it to be sawed? How dry should it be? What kind of planks? Beams? System? Etc. How should the visible wood look? How should the façade be sawed and nailed? Nobody ever thinks about this". ... (Andrén, 2015)

Referring to the theoretical framework, further articulation from lessons learned can develop a niche innovation further. Specifying the need of the client is also articulation the clients expectations which will guide other innovation activities, such as adoptions from suppliers.

Regarding the end-user preferences, there are projects regarding consumer health in relation to material choice underway (Andrén, 2015). Previous research in Europe show that consumers perceive timber as having a positive association with well-being, eco-friendliness and aesthetics (Gold & Rubik, 2009)

In summary, the clients in Växjö are working with the specifications regarding their needs. According to the theoretical frame of reference, adopting stable routines will contribute to the development of an innovation, and further articulation of expectations guide other actors. Next subsection will consider important learnings regarding business models and local developments.

5.1.5.4 Business models

Industrial building can be broadly categorized in open or closed building systems (Gustafsson et al., 2012). Open systems are component based with a large set of different suppliers, and these suppliers collaborate in order to produce a finished house A closed system is on the other hand usually provided by a single supplier (ibid). This broad categorization can be made more detailed as with the Brege et al. (2014) report, but the categorization is commonly referred to when discussing the development of industrial building. At the local scene in Växjö this discussion seems important:

"Our picture of this is that the Nordic countries are on its way into industrial processes with regards to construction systems. Where it is heading in a long term perspective of 50 years or so one can only imagine. However, if one continues with the industrial process and closed system you get stuck in corporate owned systems, which may compete well with open construction systems where components are bought from different suppliers and then assembled. That is a huge discussion right now, if one should buy CLT elements and assemble just like one does with concrete elements" (Andrén, 2015)

At the local scene in Växjö there are indications that the choice of industrial building systems affects the local entrepreneurship and the SME in the area:

"We can see, or at least suspect, that these timber construction systems that we get are more closed than open. Therefore the work contracts can be arranged a little different and smaller entrepreneurs can compete and leave a good tender." (Andrén, 2015)

A detailed local assessment of the SME in Växjö and their experience with different business models is outside the scope of this thesis. As conclude above, the local SME have adopted to timber building and there are several local subcontractors in Växjö.

At the national level, there are currently several suppliers of multi-storey timber framed buildings on the Swedish market. These actors are evident in the local cases, competing with local smaller entrepreneurs regarding timber building. The business models of some of these major timber actors are examined below.

Regarding volume element production, major actors are Lindbäcks, Moelven, and Setra. These companies have taken up the role as main contractors and uses design-build contracts, i.e. they are timber system suppliers with turnkey offerings. During the introduction of multi-storey timber solutions this business model has been vital and a prerequisite for persuading clients to build with timber frame solutions (Brege et al., 2014). The three national actors mentioned above have all developed business models toward the closed industrial building with a high degree of prefabrication.

Another well-known actor in Sweden providing prefabricated timber solutions is Martinsons, or its subsidiary Martinsons Building System AB. This company manufactures solid wood floor/wall elements (CLT) combined with glulam (Martinsons, 2015a). Martinsons work with design-build contracts and the company role varies but for the most part the firm act as a frame subcontractor (Brege et al., 2014). The building system is general and open, enabling external architects and structural engineers to work with it (Martinsons, 2015a). However, Martinsons is not a completely open system, rather a semi-open system and in the past Martinsons sometimes acted as main contractor in order to access new markets. When the market has matured somewhat and clients gain influence over the building process, and dividing procurement practices, Martinsons have developed toward the role of a material supplier (Brege et al., 2014)

A fifth actor is Masonite who provide an open building system. It consists of various timber I-beams prefabricated in Masonite's own production facility, separately prefabricated floor/wall elements made by a project specific manufacturer or through long term agreements and lastly design and assembly instructions (Masonite, 2015). Its business model is a component system supplier with technical support (Brege et al., 2014).

Brege et al. (2014) concludes that both the module element system supplier (turnkey, main contractor) and the frame system supplier are viable business models, and that the industrial builder often take on the main contractor role. The important role of the principal/main contractor regarding innovativeness has been emphasized in the literature, stating that a conventional actor in this position hinders innovativeness (Winch, 1998) The national actors has recognized the importance of this role and incorporated it into their business models.

In summary, the national actors supplying timber framed solutions learned that in order to succeed they need address the principal contractor role and increase their involvement in the design phase. Three national actor works with turnkey projects adopting the main contractor role. Another well-known actor, Martinsons, varies within these business models but strive toward the role as subcontractor with onsite assembly and design resources. One national actor is a component supplier with technical support as additional resource.

Local timber building entrepreneurs can learn from these national timber building actors. Industrial builders need to take on the role of the principal/ main contractor if the clients prefer this type of business model. If clients should increase their influence over the building processes, taking on a more open building process, entrepreneurs can shift towards component suppliers. Moreover, design competencies and in house assembly seems to be viable business models.

5.1.5.5 Summary of valuable lessons learned

Demonstration projects allowed the involved actors learn about timber building at an early stage. Regarding technical aspects Växjö municipality seems to have overcome the initial technical challenges and measurements are now focused on capturing softer values such as health correlated to timber structures, or maintenance costs for stairwells.

The benefits of building with timber are becoming increasingly clear. Arguments in favor of timber building include economics, environmental friendliness and long term flexibility. Moreover, the local demand is fueled by the commitment of the local politicians and the articulation of visions within the timber building strategy. When articulating these visions, the development of local industry and increasing the competition are important cornerstones.

Local actors are learning about business models and presently there are local discussions about the implications of different constructions systems. It seems that some indications towards benefits for local SME have been observed with closed systems, which may be a lesson learned. At the national scale, actors has initially taken up the role as principal contractor and designer when entering a new market. Some are still exploring this role, while others have are positioned toward frame system suppliers or component supplier. However there is still need for in-house competencies regarding design and assembly.

One identified problem at the local scene was the lack of documentation regarding the client needs. This is prioritized by the municipal companies. Further articulation of expectations regarding the client needs can guide other niche actor's activities and develop the timber niche further. As a client, the choice of open or closed building systems have important implications for viable business models among the local entrepreneurs. Engaging further in building processes and dividing procurement practices is one way of encouraging local entrepreneurs to take up timber building as component suppliers, as, shown in the Falun case, although this is not necessary if local timber building entrepreneurs take up the role as principal contractors with in-house design and assembly competencies.

Results have been presented regarding articulation of visions and expectations, networking and valuable lessons learning regarding the timber niche innovations. The measurement of how far the niche development has come is in the literature referred to as momentum. The next section analyses the niche momentum in Växjö.

5.2 Niche momentum in Växjö

This segment aims to describe how far this novelty have come in terms of momentum. Momentum can be considered as the strength of the niche, aiming at facilitating a deep structural transition where the socio-technical regime incorporate the niche innovation. Niche momentum depends on articulation of visions or expectations, commitments from growing networks and lessons learned. Momentum is gained if visions and expectations become more precise and broadly accepted, when lessons learned align in a "dominant design" i.e. stable configuration or when networks grow large and powerful actors commit to take up the novelty.

5.2.1.1 Acceptance and precision of visions and expectations

Regarding visions and expectations, niche momentum is gained when visions become more precise and broadly accepted. Some of the early visions were to industrialize building methods and initiate timber as a material choice when construction multi-storey houses in the region.

These early projects made for a profiling question for the municipality and this vision has been growing stronger during the last two decades.

On a national scale, expectations were articulated in 2004 with the nation timber building strategy. Visions and expectations attract attention from external investors, and external investors in this case are the municipalities with its public companies. Växjö adopted its own local strategy in 2005, revising the national strategy and adapting it to its local conditions. There were specific persons driving both national and the local timber building questions, and when their visions were articulated and adopted both nationally and locally, the timber niche momentum increased.

In 2013 the local timber strategy in Växjö was renewed with specific market share goals. The municipality is at the frontier with these goals and the vision is more precise, thus momentum has increased further. The market share goals fuel the local demand for timber building, and more actors accept and adapt to it, such as the local entrepreneurs. A fairly large share of the local entrepreneurship has committed to the timber building competing with the larger national timber building actors and large concrete actors in tendering.

5.2.1.2 Growing social networks

Niche momentum is also gained when networks grow large and powerful actors commit to take up the novelty. The triple helix i.e. the university, public sector and business sector is deemed as important for the success in timber building in Växjö. The university provides research regarding the timber building niche, whilst the public sector fuel the demand providing learning opportunities for local actors. The commitment of these three actors strengthen the local timber building, thus contribute to the growth of the local timber momentum.

Moreover, the commitment of political actors is perceived as very important by the respondent. These actors may be considered powerful at the local scene and therefore their commitment is more significant to the local niche momentum. Policy actors committed to the innovation in 2005, and even more so when revising the timber building strategy in 2013.

Formal networking such as the Nordic Wooden Cities increases the resource base with joint projects and the social resources with share knowledge. However my assessment is that this affects the national timber building momentum more than the local momentum in Växjö.

5.2.1.3 Dominant design

When lessons learned align in a dominant design and stable configuration, momentum is gained. Lessons learned from the two decades of demonstration projects have aligned the timber building niche in a stable configuration in Växjö, with all the technical challenges resolved. There is still discussions regarding business models and user preferences, and when this align in a dominant design the niche will gain additional momentum.

5.2.1.4 Conclusion

As a conclusion, the timber niche momentum in Växjö has grown so strong that timber building of multi-storey houses is becoming mainstream in the region. The previous socio-technical regime started to change when timber building was locally introduced 1992. The elements of policy, industry, technology, market, culture and science all start to adapt incorporating timber building. The local regime in Växjö are adapting to timber building,

indicating that a new socio-technical regime is formed. The transition pathways of Växjö are further discussed in the end of this thesis, see section 6.3.1.4.

The local timber building niche in Växjö has made the transition from being an underdog, to becoming mainstream. This has been shown above, assessing the developments using MLP. The transition is exemplified by the following quote:

"Then, at the present we have the upper hand now. When I started in the end of the 80ths and until some year ago, the work was as an underdog. It was hard, facing locked-in systems and you always worked as an underdog. Always fighting as heck to get your ideas and thoughts realized. Now I think, since about a year ago, higher expectations have formed….Now it is very important to know how to do it. There are expectations from everywhere, about performance and delivery, and it need to be done right… [and when talking about tenders]… Here everybody knows it already. We had a tendering for a large house at the university and I don't think we even wrote timber in the contract documents, but we got six offerings on the tender – all of them constructions with timber frames."(Andrén, 2015)

5.3 Case B Skellefteå municipality

5.3.1.1 Introduction to Skellefteå municipality

Skellefteå municipality is located in the north of Sweden at the east coast. The municipality has a population of 72 000, placing it 29th among the Swedish 290 municipalities (SCB, 2014a). The population is expected to rise, and the municipality aim at the goal of 80 000 inhabitants in 2030 (Forsman & Andersson, 2015). The local Campus house two universities, Luleå University of Technology and Umeå University. Moreover applied science actor SP Wood Technology has an office at campus.

Skellefteå is known for its mining and forestry industries, with an abundance of natural resources in the region. This has nourished a strong tradition of entrepreneurship in the region (Skellefteå Kommun, 2015a). For example, national suppliers of timber framed solutions such as Martinsons and Lindbäcks originate in the nearby area (Lindbäcks Bygg AB, 2015; Martinsons, 2015b), and Setra Plusshus has a production facility in the region (Setra, 2015).

5.3.1.2 Early demonstration projects in Skellefteå [1999-2014]

Skellefteå has a variety of timber constructions ranging from the longest timber bridge in the Nordic countries to residential housing built industrially (Forsman & Andersson, 2015). The size of the municipality limits the amount of new constructions, although timber building hold a strong tradition in the area (ibid). A brief introduction to demonstration projects ranging from 1999-2014 is presented below.

Local public housing company Fastighets AB Polaris was an early adopter of the multi-storey timber building techniques and 1999 a five-storey load bearing timber office building was built (Skellefteå Kommun & Trästad, 2015). Besides local office buildings and industry buildings, the company also own the Campus structures, with a variety of timber framed buildings constructed in the early 00ths and forward. Such buildings include a timber framed sports hall, library and a student union house made with Japanese earthquake secured techniques called Big Frame (Skellefteå kommun bygg och miljökontoret, 2012; Skellefteå Kommun, 2012).

Private actors has been clients for timber framed buildings in Skellefteå as well. During 2006-2009 multi-storey residential housing Kvarteret Ekorren was built by a housing association (Gustafsson et al., 2012). The residential buildings 3-5 stories high, contained 31 flats and was coordinated by traditional actor PEAB. The construction system involved volume elements

supplied by SETRA Plusshus (ibid). A four-storey parking garage was also built, ordered by the municipal company Polaris (AIX Arkitekter, 2012; Skellefteå kommun bygg och miljökontoret, 2012)

Another local residential project is named Älvsbacka strand. This is a residential area consisting of three seven-storey timber framed houses, built 2008-2010 (Skellefteå Kommun, 2012). The project was a joint venture named Bygg I Trä AB, constituting the architectural firm White, local entrepreneur Martinsons Byggsystem and Lindbäcks Bygg AB (Westerlund, 2012). The ambition was to develop a new industrialized building system for timber (Westerlund, 2012; White Arkitekter AB, 2015). Moreover, the project was awarded Gold in the certifying system Sweden Green Building Council (Gustafsson et al., 2012).

Älvsbacka Strand were in 2011 connected to the other side of the river floating through Skellefteå. This was no ordinary bridge, but a 130m timber bridge, built by the municipality of Skellefteå (Skellefteå kommun bygg och miljökontoret, 2012; Westerlund, 2012). The area became more attractive, spurring further investment nearby. In 2013, Lindbäcks Bygg AB finished another 59 flats in nearby *Älvsbacka Park*, built with the company's own building system and with Lindbäck and NV Fastigheter as a joint venture client. (LindBäcks Bygg AB, 2011)

5.3.2 Skellefteå's articulation of expectations and visions

Processes for establishing expectations and visions include articulation and adjustment of expectations or visions. This provide guidance in the innovation activities and attract attention from external actors.

The timber building in Skellefteå originate from a strong tradition of timber craftsmanship and forestry, and an abundant local resource. Presently timber building is perceived to add to the profile the municipality wants to achieve:

"It does not hurt anything if Skellefteå is perceived as a city of wood…. It's like our municipal commissioner said, or the politics in general, this is important for the identity and the profile Skellefteå wants. We want to be a city of wood and build with timber, it is part of our legacy and identity. "(Forsman & Andersson, 2015)

Historically, local people in public positions have been driving the timber question both at a local level and at a national level (Forsman & Andersson, 2015). Representatives from Skellefteå engaged in the national timber building strategy 2005 and thereafter in the related project Trästad 2012 (ibid), where 17 municipalities collaborated in order to develop the Swedish timber building (Westerlund, 2012). Currently there is a local group called Trästad Skellefteå, which has worked with a local timber building strategy since 2012:

"Working at the national level is one task for Trästad Skellefteå, but another goal is to establish a broader engagement in the local municipal organization and the local property companies. We have worked with this local timber building strategy starting already in 2012 and finished it during 2014."(Forsman & Andersson, 2015)

The quote shows that a timber building strategy has been underway since 2012. In late 2014, this local timber building strategy was adopted by the city council (Skellefteå Kommunfullmäktige, 2014). During 2015, this timber building strategy is implemented in the public companies and administrations, with the aim of anchoring the timber building further in the public organization (Forsman & Andersson, 2015).

In more detail, the strategy states that all municipal companies and administrations will: (Skellefteå Kommun, 2014)

- examine timber in all building and construction projects
- prioritize timber when it is technically and economically justified
- examine timber building in the initial physical planning
- present reasons for another material choice than timber and how the knowledge of timber building can increase (ibid)

The timber building strategy is motivated by arguments in three segments: environmental (sustainability concerns), development of local enterprise and community development (Skellefteå Kommun, 2014). A future vision is also articulated where the municipality of Skellefteå acts as role model regarding the community attractiveness, technical frontiers and sustainability (ibid). Thus the timber building strategy seems to be mainly framed after landscape environmental pressures, and with a focus on local SME development.

In a broader perspective, the timber building strategy is part of an overall sustainability and attractiveness strategy for the municipality (Forsman & Andersson, 2015). As the population grows in the region, a stable long term demand for both housing and job opportunities is expected (ibid).

With the adoption of a local timber strategy, the ambition for the municipality is to drive innovations and timber development (Forsman & Andersson, 2015). As a client, or investor, the public sector can choose to promote the local industry and work for other public goals such as sustainability and community development (ibid).

5.3.2.1 Regime lock-in

Niche actors hope that the innovations eventually will be adopted in the regime, or even replace it. Lock-in mechanisms and disparity with existing regime dimensions such as infrastructure, regulations or consumer practices makes transitions hard, and few niches succeed in this (Geels, 2012; Smith et al., 2010).

An official report of the Swedish Government regarded the public procurement legislation, and one conclusion was that the large proportion of appeals cause delays and problems (SOU, 2013). For clients, there is a serious risk of getting involved in complicated legal matters which reduces the incentives for innovative contracting methods (ibid). Urban planning has a history of problematic appeals, and in 2012 about a fourth of all municipal zoning decisions were appealed (Boverket, 2013). The previous building minister in Sweden Stefan Attefall also acknowledged that the rules needed evaluation (SVT, 2012).

The local timber building strategy in Skellefteå does not specify local market share goals for timber building Minimizing the risk for appeals may be reasons for not articulating market share goals in the timber strategy. Similar to Skellefteå, when Växjö adopted its first strategy in 2005 no market goals were articulated either.

The appealing processes are driven by actors with vested interests. During the interviews in Skellefteå it became evident that there are local concerns regarding these appeals. However, there is an ambition to find out how far the client can influence the choice of suppliers and building system (Forsman & Andersson, 2015):

"It is not possible to say that we will build with timber. Växjö has done it yes, but it is not possible to be too specific because of appeals and vested interests. One should always think of the fact that free competition rules. One cannot point with the whole hand and say this is what we are going to do, there are laws and regulations that direct out behavior"…"Also, we need to challenge [conventional systems], where are our limitations and what freedom do we have? Something like that, challenge this question. Can we choose timber as a material from certain specifications because it is our choice of a range of selections? Then we have free competition anyway. "(Forsman & Andersson, 2015)

Lock-in mechanisms make transition from niche to socio-technical regime hard. For example, conventional actors perform political lobbying in order to their protect vested interests. When Skellefteå were about to adopt their timber strategy in 2014, it attracted the attention of a conventional concrete branch actor. The CEO of Svensk Betong visited Skellefteå previous the decision making regarding the timber building strategy. This CEO argued against the adoption of the strategy and questioned the sustainability of timber compared to concrete (Skellefteå Kommun & Trästad, 2015; Svensk Betong, 2015).

The interviewees recognize other lock in characteristics as well, such as path dependencies with the industry:

"Yes it is a traditional sector. And with regards to timber, the big companies building systems are completely directed towards concrete. They have no methods for using and developing timber. Also they have created large economic incentives to choose concrete because they have own the whole supply chain and have other concrete related businesses." (Forsman & Andersson, 2015)

5.3.2.2 Summary of articulation of visions and expectations

Skellefteå has built a variety of timber demonstration projects, especially during the last decade. Early visions that flourished were role modeling and developing the local industry. Early projects included a timber framed parking garage, some residential houses and a long timber bridge were built. Visions about developing new industrial methods was also articulated when building Älvsbacka strand, which was a joint venture of known timber actors.

In 2014 expectations and visions were articulated further in a local timber building strategy adopted by the city council. This strategy incorporates timber use guidelines for public companies and administrations and aims to anchor timber building further within the municipality. The strategy builds upon environmental sustainability, community development, and business development. Increasing the city attractiveness is also an important part of the strategy.

There are no market share goals in the strategy, probably due to fear of appeals and vested interests. Some regime lock in characteristics are evident in the region, such as political lobbying in favor of concrete building.

5.3.3 Processes for establishing and running social networks

The theory section emphasizes the processes of establishing and running social networks. Network processes include establishing social networks and the enrollment of more actors, which expands the social and resource base of the niche-innovation. Enrollment of more actors includes investors, who in this theses are clients in the form of municipalities and suppliers of timber framed components and building services.

5.3.3.1 Triple Helix, Quattro Helix and political commitment

Triple Helix, local craftsmanship and a closeness to the forest resource are historical reasons for the development of timber building in Skellefteå (Forsman & Andersson, 2015).

As far as networking is concerned, Skellefteå has a similar setup as Växjö. Networking between university, business and public sector is evident, and commonly referred to as triple helix (Morén & Hård af Seferstad, 2010). This networking across multiple elements is deemed important for the timber development in the region (Forsman & Andersson, 2015). A concrete example of this setup is the Älvsbacka timber bridge. This bridge is the longest timber bridge in the Nordic area, and span 130m across the river in Skellefteå. The idea originated from employees at the University who visited USA and later contacted a local bridge building company (ibid). The municipality adopted the idea, acted client, and built the bridge 2010 in collaboration with Martinsons Träbroar AB (Martinsons Träbroar AB, 2010)

The adoption of a local timber building strategy can be seen as a commitment of policy actors. During this process, some discussions arose regarding the nomenclature of Triple Helix, and the word Triple Helix was replaced with Quattro Helix, incorporating the civil society as well as university, public sector and business sector (Skellefteå Kommunfullmäktige, 2014). The Quattro Helix considers non-profit actors as well, who may enhance the promotion of innovations if included in the collaboration (Lindberg, 2010).

Apart from the ambition to create Quattro Helix environment in the municipality, Skellefteå is engaged in a local group called Trästad Skellefteå. At the local scene, the purpose of Trästad Skellefteå is to work for the city's attractiveness and sustainability, networking and profiling towards industrial building with timber (Skellefteå Kommun, 2015b). Trästad Skellefteå is a local part of a national timber building network called Trästad.

The resources committed to Trästad and Trästad Skellefteå is perceived to be less than before. Some of the work in Skellefteå is voluntary, focusing on internal marketing and networking. Presently Skellefteå has a part time employee working with timber building questions, but it is perceived that timber building would develop further if more resources were dedicated to the matter. (Forsman & Andersson, 2015)

The theoretical framework states that the participation of large actors will increase the momentum of an innovation. The respondents recognize this when asked if any actors are missing in the networks:

"One part of the vision with Trästad is that it will be a significant power that can influence the timber building. If everyone has not joined we miss actors. But first and foremost, it would be great if large municipalities such as Stockholm, Gothenburg and Malmo would join, places where there is a lot of construction going on."(Forsman & Andersson, 2015)

5.3.3.2 Local entrepreneurship

In the nearby area of Skellefteå, large national timber actors such as Setra Plusshus, Lindbäcks Bygg AB and Martinsons have production facilities (Lindbäcks Bygg AB, 2015; Martinsons, 2015b; Setra, 2015). Thus, the local presence is strong from these companies and they are important employers in the region (Forsman & Andersson, 2015).

The amount of timber tenders is not a huge problem according to the interviewees (Forsman & Andersson, 2015). However, there has been some setbacks. The largest municipal housing company in the region, Skebo, is currently constructing two major residential projects in

central Skellefteå. Both of these projects are built with conventional concrete building methods (Skebo, 2015a, 2015b). According to the CEO, one of these projects (Hiemdall) was adapted for timber building in the design phase but no offerings were made from timber actors (SVT, 2014). Skebo asked for a main contractor and only one conventional offer was made, thus concrete was chosen as a material. (Forsman & Andersson, 2015). The lack of timber offerings at this project were due to full order stocks (ibid).

Most of the nearby actors supplying timber solutions for multi-storey constructions are active on the national market. The national demand for timber framed houses has grown recently and is expected to keep growing according to one of these actors (Lindbäcks Bygg AB, 2014).

There is a limited production capacity and if the market demand will continue to grow it is not possible to produce the required volumes (Forsman & Andersson, 2015). Although some investments by timber actors are currently underway, such as a new production facility from Lindbäcks Bygg AB (LindBäcks Bygg AB, 2014), supply is likely to remain insufficient in the near future.

5.3.3.3 Formal networks

Representatives from Skellefteå engaged in the national timber building strategy 2005-2008 and thereafter through Trästad 2012 and other timber building projects. Trästad 2012 is an old project within timber building network Trästad. Trästad 2012 ended abruptly and Skellefteå are currently picking up the loose ends of this (Forsman & Andersson, 2015). Skellefteå is also a member of Trästad, a national timber building network open for municipalities, clients and provinces in Sweden (Trästad, 2015).

The participation in national networks such as Trästad is perceived to strengthen the influence over suppliers of the municipality, which is exemplified by the following quote:

"We are not so strong as a sole municipality, only locally. If we chose a direction it will only affect the major corporations at a local scale. When we join the national Trästad project, and become a bigger network, we can develop the interest of timber building with several other municipalities. That's when we are starting to get a significant impact and can influence the major construction companies." (Forsman & Andersson, 2015)

The quote highlights that there are ambitions of gaining power over major construction companies within the timber building network Trästad. According to the theoretical framework, networking expands the social and resource base of a novelty, which also increases the power of the niche. Moreover, when powerful actors commit to the niche, the niche momentum increases. When asked if it was perceived as a good thing if a conventional actor took up timber building the following statement was made:

"Absolutely, that would have been the dream. But I think the SME needs to grow and show that this is a successful concept. Then the big actors may join in. If they stand fast with their concrete the SME will grow even more. If the market share grows, which I am certain it will, then I think that sooner or later the big actors need to take on timber building. " (Forsman & Andersson, 2015)

In addition to networking in Trästad, Skellefteå is a member or Nordic Wooden Cities (Nordiska trästäder, 2015b). This international network is mainly used as a learning platform for the members, and technical visits from other countries is not uncommon (Forsman & Andersson, 2015). Some joint projects are started as well (ibid).

5.3.3.4 Summary of networking activities

The municipality of Skellefteå works locally with Triple or Quattro Helix, the group Trästad Skellefteå and some voluntary work. Local politicians committed to timber building in 2014 and public housing companies and administrations are perceived to be important future investors.

The region is known for its entrepreneurship and several national timber building actors originate in the nearby area, however there is a need of more local actors offering main contracting since the national actors have full order stocks.

At a wider level the municipality participate actively in national networks such as Trästad and Nordic Wooden Cities. These networks are mainly used as a learning platform but the ambition is to gain power and influence the construction industry. In accordance with the theory, respondents perceive large public actors such as Stockholm, Gothenburg or Malmö important for gaining power over the socio-technical concrete regime.

5.3.4 Learning and articulation processes on various dimensions

Learning and articulation processes refer to valuable lessons being learned by niche actors regarding technical design, market demand, user preferences, and appropriate business models. It may also include experience regarding infrastructure requirements, organizational challenges and policy.

The theoretical framework assess that niches are often carried by experimental or demonstration projects, which allow actors to learn about innovations in real life circumstances. Skellefteå as a public client has experience from housing company Polaris, mainly from Campus buildings and office buildings. As for residential housing, private actors has initiated several projects during the mid 00ths. Älvsbacka park was one example where a new building system was initiated and learnings from this project benefited White architects, Lindbäcks Bygg and Martinsons (Westerlund, 2012). One of the houses was measured extensively for energy efficiency and were awarded by Sweden Green Building Council (ibid). This contributed to the knowledge about building energy efficient multi-storey timber houses in a cold climate.

5.3.4.1 Technical aspects

As mentioned in the Växjö case, technical solutions exist for all the traditional challenges. Still there are lingering beliefs about acoustic problems and fire safety at the local scene (Forsman & Andersson, 2015). Even if technical solutions exist not everybody embrace it immediately (ibid).

There has been some local discussions on what the definition of a timber house really is (Forsman & Andersson, 2015). The usual frame definition is not applicable on a hallway building where the frame is a smaller part of the total material (ibid). These discussions can be seen as a as a learning progress regarding articulation processes. According to the theory, the articulation processes is part of the learning processes which ends up in a stable configuration.

Additionally, there are local discussions about painting systems for multi-storey timber facades, and uncertainties exist regarding maintenance of these (Forsman & Andersson, 2015). Single housing in Sweden is in 90 percent of the cases made out of wood, with various painting systems available at the market (Gustafsson et al., 2012). Since it is a tradition in Sweden to use timber facades, painting systems for multi-storey timber buildings is a current

technical issue. The lack of knowledge regarding maintenance on facades hinders the development of the timber building niche (Forsman & Andersson, 2015). For example, when clients choose façade, a common sales argument amongst glass suppliers are that wood façade need maintenance every ten year, even though paint supplier specify it to twenty years (ibid).

Currently technical research at the Campus in Skellefteå is focused on making timber more resistant and reduce the need of maintenance. Moreover, a current challenge is to specify the reduction of carbon emissions when choosing a specific material. To economically evaluate and value the environmental savings regarding industrial timber building may add to the arguments in favor of timber building (Forsman & Andersson, 2015).

5.3.4.2 Market demand

The local demand for timber buildings in Skellefteå is driven by the public and private clients and the nearby timber actors such as Martinsons. As discussed in the beginning of the case one residential project was a joint venture between Lindbäcks, Martinsons and White architects.

The newly adopted timber strategy may influence public clients to build more with timber, although impact on the local demand is hard to anticipate. However, if demand grows, the local industry may not be able to supply timber solution due to full order stocks (Forsman & Andersson, 2015).

According to one respondent, there are advantages when handling market demand with conventional building techniques. Conventional construction industry handles variations in demand by varying the workforce, which is easier when building with onsite temporary factories (Forsman & Andersson, 2015). Timber actors involved in offsite prefabricated industrial building, needs to invest capital in factories. This call for a more stable and mature demand since variations cannot be handled as easy (Forsman & Andersson, 2015). In general, industrial production made to order builds on managing demand (Olhager, 2013). Creating a stable demand for multi-storey buildings is therefore a priority for municipalities if industrial building shall develop further.

5.3.4.3 Business models

The business models for national actors are described in more detail in the Växjö case. Regarding business models and lessons learned in the municipality, this mainly concerns contracting forms. The administrative sections of the municipal organizations tend to use a form of contracting where the public clients are responsible for the design phase and the rest is procured publically (Forsman & Andersson, 2015). This is done in roughly 80 percent of the cases, and main contracting is avoided, which is necessary in order to gain control over the products that are ordered (ibid).

According to Winch (1998) the main contractor role is a system integrator and necessary in order to gain power. In Skellefteå main contracting is avoided and procurement is divided in order to gain control in the project design phase. As detailed in the Falun Case section 5.4, there are different approaches in order to gain control in the building processes.

New timber buildings and timber constructions are expected to generate new business in the municipality (Forsman & Andersson, 2015). One external example of houses that attracted some attention recently is the residential timber housing in Sundbyberg, a small municipality close to Stockholm. These multi-storey houses were built by Folkhem with Martinsons as

supplier and have generated a lot of publicity for the community and client Folkhem (Folkhem, 2013). In Skellefteå, business opportunities like this are expected to arise from similar types of buildings:

"It's interesting and that's how we think here, that the interest for our constructions and factories will generate a significant business for the municipality in form of technical visits. People should want to come here and look at the knowledge, competence and industry that we have here. "(Forsman & Andersson, 2015)

The respondents continues stating that industrial building has the potential to be more effective than conventional building techniques, not only economically but also regarding innovations and socio-economically. If the production of housing in Sweden continue to be decentralized and with rural connections, then it contributes to a different allocation of the workforce in Sweden (Forsman & Andersson, 2015). This may benefit rural municipalities such as Skellefteå.

5.3.4.4 Summary of lessons learned

Most of the demonstration projects in Skellefteå are still fairly new and in limited numbers, i.e. the learnings from demonstration projects are limited. Most actors in the nearby area are however active on the national market providing learning opportunities all around Sweden.
Technical aspects are mostly solved, but traditional beliefs still linger. Other challenges are maintenance and painting systems of multi-storey timber buildings, and the local university conducts research in these areas.

The impact of the timber building strategy in local market demand is hard to anticipate. Full order stocks and low production capacity in the timber niche may hinder full exploration if the demand should rise. At the national market demand is anticipated to grow, which could generate investments in production facilities since demand becomes more stable and mature. Conventional construction sector handles demand variations with human resources management. Since industrial builders bind capital in factories, a stable demand is important for the industrial timber building development.

In addition of encouraging local SME:s and increasing competition within the construction industry, Skellefteå expect that new timber construction, bridges included, generate a side business with technical visits.

5.3.5 Niche momentum in Skellefteå

This segment aims to describe how far this novelty have come in terms of momentum. Momentum can be considered as the strength of the niche, aiming at facilitating a deep structural transition where the socio-technical regime incorporate the niche innovation. Niche momentum/development depends on the subsections above; articulation of visions or expectations, commitments from growing networks and lessons learned. Momentum is gained if niche related visions and expectations become more precise and broadly accepted, when lessons learned align in a "dominant design" i.e. stable technical configuration or when networks grow large and powerful actors from the socio-technical regime commit to take up the niche innovation.

The timber building in Skellefteå originate from a strong traditional craftsmanship and an abundant and close resource. Some national industrial timber builders resign in the nearby area as well and the city's identity is connected with wood as a material. The municipality has a history of forestry and strong local business related to forestry, why the identity relates to the material.

Niche momentum is gained when articulation of visions and expectations becomes more precise and accepted. Visions of increasing the multi-storey timber building in the city has circulated since 1994, with local persons driving the matter. However, in 2014, a timber building strategy was adopted in the city council, embodying the early visions and the timber building identity. The momentum of timber building in Skellefteå has therefore increased with the adoption of this strategy.

The strategy is new and the outcomes are yet to be seen. Compared to the strategy in Växjö, there are no specific market share goals in the Skellefteå strategy. Specific market share goals drives the local demand for timber building further and thereby increase the amount of demonstration projects and lessons learned. Specific market share goals also articulate the visions at a more precise level. The local niche momentum regarding articulation of visions and expectations is therefore not as strong in Skellefteå as in Växjö.

Niche momentum grows when networks grow and powerful actors commit to the innovation. One important implication of the adoption of a timber strategy is the commitment of local politicians. When local policy actors committed to the timber building innovation, the niche momentum increased. However, at the level of officials there is a perceived need of more resources for working with networking and implementation of timber building related matters.

Similar to the Växjö case, Skellefteå has worked with a triple helix environment which is a commitment of three actors; University, public sector and industry. This too has strengthened the local momentum, initiating learning projects such as a 130 m timber bridge and research regarding timber building at the University.

Local timber building actors engage in the national market, with a limited supply capacity. Thus, there has been a lack timber tendering on new buildings in Skellefteå, even though the clients adapted the specifications to suit timber offerings. This indicate that there is a need to stimulate the local timber building industry and increasing the supply capacity. As a public client, demand can be increased creating incentives for local development of timber building industries.

Skellefteå is participating in formal national and international networks. The larger municipalities such as Stockholm, Gothenburg and Malmö are perceived as missing actors in these networks. According to the theory these actors would increase national momentum of the timber building innovation since they are powerful municipalities in terms of buildings constructed.

When lessons learned align in a dominant design and stable configuration, niche momentum is gained. The demonstration projects in Skellefteå are varied and scarce, limiting the learning opportunities. Thus the public clients has limited experience of timber building. Nearby private actors such as Martinsons and Lindbäcks have experience from building with timber on the national arena, and are leading actors within timber building. These actors have established a dominant design regarding production, which increases the local niche momentum since knowledge about a stable configuration exist nearby. However, the public clients need to develop organizational competencies regarding timber building

5.3.5.1 Conclusion

In conclusion, Skellefteå has increased its local momentum due to the adopted timber building strategy in 2014 (articulation of visions becoming more broadly accepted). The articulation of

market share goals would strengthen the momentum further. However, some indications of regime lock-in behavior such as political lobbying may slow this process.

Previously, timber niche momentum has been built up by the collaboration of university, public sector, and business (triple helix) and formal networking. Yet, learnings from timber building has not yet yielded a dominant design regarding the public client role, and the timber building strategy is new and need implementation.

5.4 Case C Falun municipality

5.4.1.1 Introduction

The municipality of Falun is located in the province Dalarna and the municipality host approximately 60 000 inhabitants (SCB, 2015). Both the cities Falun and nearby Borlänge (Borlänge is a separate municipality) are university towns with campus of Dalarna University (Dalarna University, 2015) The region has a strong tradition of building with timber, and some timber structures go back to the 13th century (Falu Kommun, 2014) .

In 2013, Falun distinguished themselves from other public actors with the use of Building Information Modeling (BIM) and Integrated Construction Engineering (ICE). Moreover, in 2014, the municipal building administration started working with innovative procurement methods, with the aim of increasing innovation within construction.

Public procurement and Falun's innovative organization measures constitute the bulk of the Falun case. However, a brief assessment of the timber building niche is presented.

5.4.1.2 Timber building projects in Falun

Falun participated in the national timber building strategy during 2005-2008. As a result, the municipal housing company in Falun, Kopparstaden, built two timber framed houses in 2005-2008, four and five stories high called Hyttkammaren. (Westerlund, 2012). This was a first attempt to build with industrial timber building methods in the municipality, and the learnings were used to formulate a timber building strategy. This strategy is presented below in section 5.4.2.

In 2014, the building of an energy efficient and environmentally friendly school was finished in Falun. This building was part of a three year project called MountEE. MountEE is a EU project supporting municipalities in building sustainable and energy efficient (MountEE, 2015). The participation resulted in a school built with massive timber floor structure. Moreover, energy and environmental demands were articulated in the public procurement specification (Wiking, 2015b).

Subsequently, 32 hi-tech flats for elderly care was finished 2014 in a building process named Kårebacken. The procurement process used learnings from another project in Falun, namely EU project Innobuild (Wiking, 2015b). Innobuild is considered in more detail in section 5.4.4.4.

Moreover, the municipality hosted the cross country ski world cup in 2015. In preparation of this event, an sport administrative building was built by Stora Enso (Stora Enso, 2015). Stora Enso is main sponsor of the event and built the two-storey house timber house using CLT supplied from its factory in Austria (Stora Enso, 2015)

5.4.2 Processes for establishing expectations and visions

Articulation of expectations aim to attract investors for external funding, and also provide strategic guidance to innovation activities.

In 2011 Falun municipality adopted a timber building strategy (Westerlund, 2012). The strategy stated that timber as a building material should be considered in public construction matters, and applies to all public companies in the municipality (Falu Kommun, 2011). Finished projects are to be evaluated with regards applied or alternative timber building methods, and the material will be considered in the urban planning processes and when selling land (ibid).

Visions articulated in the strategy state that the strategy should strengthen the profile in Falun as an energy efficient and sustainable municipality (Westerlund, 2012). Also, the local timber industry should be stimulated with increased focus on the material (Falu Kommun, 2011). Lastly, the city attractiveness can be improved with new timber architecture (ibid).

The underlying reasons for the strategy have been to reduce building costs and develop local SME. This relates to landscape developments of increasing building costs and also regime power structures where a few major contractors dominate the market:

The articulation of a timber building strategy has guided actions from officials and public administrations, supporting decisions made by public staff (Wiking, 2015a). However, the strategy is currently under review and it may be that market share goals is the next step forward in the timber building strategy (Wiking, 2015a):

"The strategy is under review. It is a little too old and thin. On the other hand, it specifies what we do. It has been a trigger for us, where we can show why we do it this way. It has to do with SME and cost-effective building"…"There is one mission right there, how do we lower the building costs? If we work with traditional total contracting it will be the same 2016, 2017 and 2015. We need to find new approaches." (Wiking, 2015a)

The quote emphasize that new approaches are needed in order to facilitate a change towards increased timber building in the municipality. Falun has worked in various ways (see section 5.4.4 for specifics) in order to articulate visions and expectations further. This especially applies in local public procurement, where visions have been to increase innovation (and hi-tech oriented solutions) and develop more flexible and target oriented methods for purchase (Wiking, 2015a). Moreover environmental and sustainability demands have been articulated in procurement processes (ibid)

Local networking is used to articulate visions. Falun participates in a local network 'ByggDialog Dalarna' which is described further in the section 5.4.3.1 This network is used to articulate visions and guide other actors:

"The Dialogue builds upon that we can, at one location, discuss questions that affect other actors by telling them where we are going. Then the contractors get an insight – how should we adapt? I for example say, how can you match this? How can you, as a supplier, match this type of specification?" (Wiking, 2015a)

5.4.3 Processes for establishing and running social networks

Building new networks and involving more actors expands the social and the resource base of niche novelties, see section 2.2.3.1 for details.

Before the articulation of a timber building strategy in 2011, local politicians were engaged in timber building matters (Westerlund, 2012). There were informal ties to national networks (such as the national timber building strategy and Trästad) and other timber building municipalities such as Växjö and Skellefteå, which in the end resulted a timber building strategy (Wiking, 2015a). However, other measurements than articulating a timber building strategy has been undertaken. At the local scene, an informal group consisting of administrative leaders and politicians recognized "that a timber building strategy does not actually build anything" and decided to take further action on the administrative staff level (ibid). This was the start of projects like MountEE and Innobuild, which are detailed in the introduction of this case and in section 5.4.4.4.

Projects like MountEE and Innobuild are in themselves small networks of similar actors, mainly public clients. The Innobuild project involves a Norwegian municipality named Lyngdal, which in turn has connections with Norwegian state actor Agency of Public Management and eGovernment. According to the theory, these networking activities can be seen as involving more actors and increasing the social resource base of the niche innovation.

5.4.3.1 Formal networks

The municipality participate in several formal networks, such as ByggDialog Dalarna and Trästad. ByggDialog Dalarna is a regional network concerned with local construction matters. The network involves regional industry actors the University of Dalarna (Byggdialog Dalarna, 2015). Regarding timber building, a theme group has been started with the goal of involving ten municipalities in the group (Wiking, 2015a).

Three nearby smaller municipalities have committed to building with timber by adopting timber building strategies (Westerlund, 2012), although their commitment vary (Wiking, 2015a). Getting more municipalities involved in timber building is perceived as very important and contribute to anchor the timber building on a broader regional scale (ibid). This is especially important for smaller municipalities:

" We are a middle ranged municipality, but I think smaller municipalities need partners. Smaller municipalities might build every five years, and there is a need for competence which is hard to employ. When they are building a school in Vansbro or Malung, we should collaborate so they get our competence."(Wiking, 2015a)

According to the theory, networking adds to the resource base of the innovation. This includes social resources and competencies. This is recognized in ByggDialog Dalarna where smaller municipalities can draw upon increased social resources.

5.4.3.2 Local industry

The local industry in Dalarna is currently composed of small house manufactures such as Dalahus (Wiking, 2015a). Regarding multi-story housing and industrial building, forestry actors have tried to establish factories without success. Cross-laminated timber producer KLH started to set up a factory in nearby municipality Orsa in 2005, but then decided to withdraw its plans since the Swedish market demand was too low at the time (DT, 2012). Moreover, forestry and pulp/paper actor Stora Enso set up an administrative unit in the municipality of Falun (Wiking, 2015a). This unit was going to prepare for a production facility in the region, but the project was never fully executed (ibid).

The demand on the national market is currently higher than the supply from the national actors (Wiking, 2015a). Therefore, a business opportunity for SME exist, and local small-house

producers could increase their flexibility and competence regarding larger timber framed buildings (ibid).

Some lock-in tendencies from traditional actors have slowed the process of developing local timber building SME in Falun. There are local housing industries that potentially could supply timber frames for multi-storey buildings. However these single-family house producers do not provide turn-key solutions and are dependent on traditional contractors in the production phase (Wiking, 2015a).

There are problems related to this. For example, in one project where Falu municipality had an ongoing public procurement process, a small house producer wanted to leave a timber frame tender. However, this tender never reached the public client, since the main contractor decided not to forward it the client (Wiking, 2015a). This relates to viable business models discussed in Växjö case, section 5.1.5.4. Main contractors have been identified as a barrier within the construction system, preventing innovating solution to reach the client (Winch, 1998). This is recognized in Falun, and has prompted local public clients to gain influence over the construction process, taking on the responsibilities of the main contractor. The actions conducted are assessed in detail in the next section, 5.4.4.

5.4.4 Learning and articulation processes on various dimensions

Learning and articulation processes refer to valuable lessons being learned by niche actors regarding technical design, market demand, user preferences, and appropriate business models. It may also include experience regarding infrastructure requirements, organizational challenges and policy.

The next section describes the learnings from a number of incentives from Falu municipality regarding increasing innovation, local businesses and sustainability.

5.4.4.1 Technical learnings from BIM

In 2013, Building Information Modeling (BIM) was implemented in the municipal organization (Falu Kommun & Trästad, 2014). BIM is a process that involves digital representation of functional characteristics of places (ibid). In Falun, this is generated by 3D scanning of the interior and exterior of all the public buildings, resulting in a digital image (Wiking, 2015a). Using BIM increases the technical competencies in the municipal organization, and enable further planning ahead in building processes. This improvement enable industrial building methods that require a more detailed design phase (Backlund, 2014)

Subsequently, an organizational change was implemented called Integrated Construction Engineering (ICE), making use of the technical learnings from BIM. ICE is described further below.

5.4.4.2 Organizational experience

In 2013 Falu Municipality started working with ‘creative environments’ or Integrated Construction Engineering (ICE). In this organizational change, the consultants i.e. architects and structural engineers, are physically located in the same building as the client administration office. Consultants work in the same room, enabling instant problem solving face to face. The municipality supplies the digital infrastructure (coordinating computer program through licenses) and BIM (3D scanning) (Wiking, 2015a). The result is a faster design phase and improved problem solving, and lower project costs (Wiking, 2015b). One aim with this organizational change is to create an internal competence cluster so the public

clients can articulate their needs better (Wiking, 2015a). Moreover, it makes future collaboration with smaller municipalities possible by partnering or selling services (ibid).

Regime lock-in tendencies such as lack of timber building knowledge among architects and structural engineers have been overcome by framework agreements. For example, architects schooled in timber building have been hired to educate other architects in cost effective design of timber structures (Wiking, 2015a).

5.4.4.3 Divided contracting in public procurement

Since 2014, Falun Municipality has been working with divided public work contracts. Contracts are divided into smaller parts, with Falun taking a greater responsibility as a client and moving away from traditional subcontracting with main work contracts (Wiking, 2015a).

The traditional total entrepreneur (main work contractor) have been identified as a barrier for innovation (Winch, 1998) and dividing the work contracts remove barriers for SME:s. This is also acknowledged by the European Union, who recently considered this in a new directive for public procurement (Council of the European Union, 2014).

Public work contracts in Falun are divided in ground preparation, frame and frame assembly, installations, and ground finishing (Wiking, 2015b). This enable public clients to procure work contracts when subsequently working on the design phase. Additionally, more control over time schedule are acquired (ibid).

Dividing procurement contracts requires an active and clear client role (ibid). Parallels can be drawn with the open timber building system described in the Växjö case. Open systems are component based with a large set of different suppliers, and these suppliers collaborate in order to produce a finished house (Gustafsson et al., 2012). In Falun, these multiple suppliers are coordinated by the public client instead of a subcontracted principal contractor.

The use of divided public work contracts has required some organizational changes in Falun. For example, leaders BAS-P and Bas-U are provided by the municipality (Wiking, 2015a). BAS-P refers to staff coordination of design phase and BAS-U in the construction phase (Mårtensson, 2015). The involvement in the project Innobuild incorporate both divided contracting and innovative public procurement methods. This is further detailed below.

5.4.4.4 Policy – Public procurement project Innobuild

Experience from the MountEE project resulted in insights regarding the combination of timber building and energy-efficiency. Moreover, Falun municipality had realized the limitations of traditional procurement, where main contracting result in the “same thing” year after year (Wiking, 2015a). In MLP, this can be viewed as regime lock-in characteristics (read more in section 2.2.4).

Together with Norwegian municipality Lyngdal, the municipality of Falun participate in a three year project called Innobuild. The project is funded by EU and Norwegian and Swedish agencies and aims at develop the process of public procurement (Innobuild, 2015). Innovation and sustainability are focal areas (ibid). The project method deals with procurement in three stages:

Stage 1 encourage contracting authorities and suppliers to re-think their needs. Such needs considered in Falun were an environmental friendly building with little maintenance and

technical solutions that prevented strain of staff and improved living conditions for seniors with complex needs (Falu Kommun & Trästad, 2014). Other stakeholders such as health care personnel, technical staff, senior citizens and relatives were consulted when identifying needs, resulting in increased consideration of the building end users (ibid). End users traditionally have low influence over building specifications (Sou, 2002), so this is an important improvement.

The identified needs were similar for both Falun and Lyngdal. Therefore the project aimed for a joint procurement. Possible solutions from suppliers were identified through "speed dating" i.e. short market consultations with the aim of identifying state-of-the-art innovative solutions. These market consultations were made separately at local places and together at conference hearings in Brussel and Stockholm (ibid). The result was functional specifications articulating needs for procuring innovative and sustainable solutions (Innobuild, 2015).

Stage 2 intended to implement a joint procurement agreement between the two municipalities (Innobuild, 2015). Due to differences in national legal frameworks this was not possible and two separate tender processes was initiated in Mars 2014 (Falu Kommun & Trästad, 2014) In order to support competition from SME, a limited compensation was paid to all tenderers. This minimized the risk for small niche actors when working on tenders, since this process usually is a large cost for minor actors (ibid). Lastly, Stage 3 encompass raising awareness of the results and produce a manual (Innobuild, 2015).

Currently, stage 1 is finished in the project, and procurement of architects in stage 2 of have been completed. In Falun, half of the tenders met the needs specified and the other half was traditional offerings that did meet the needs, however the company placing last contacted the winning company in order to learn from its mistakes (Wiking, 2015a). This indicate that SME adapt and learn from the processes. From an MLP perspective, the procurement in stage 2 is an articulation process of the expectations from the client, which guides other actor innovation activities.

The winning architectural firm was evaluated on a basis of four categories, functional program (space, tech, ventilation, staff needs, interior, exterior etc.), development areas (construction time, construction cost effectiveness, maintenance, required staff etc.), innovation level and price (Falu Kommun & Trästad, 2014). This differ from traditional procuring, that mainly focus on price (SOU, 2013).

Learnings from Innobuild stage 1 was applied on an ongoing parallel project, an elderly home construction project with 32 flats finished 2014 (Wiking, 2015b). In this project Falun used divided contracting and timber volume elements, resulting in experience and shorter construction time (ibid).

5.4.4.5 Further organizational experience from Construction Management

Generally, Falu municipality has implemented BIM, ICE, divided contracting and tried innovative functional procurement. Construction Management (CM) is the common denominator for these actions. Construction management involves client project management with a total responsibility for the finished project (Backlund, 2014). The aim is increased competition when procuring, lower costs, shorter lead time (from idea to finished product), and an increased influence over the building process from the client (ibid).

Construction management can be compared to taking over the role as main contractor, or principal contractor. According to Winch (1998) structural engineers, architects and principal contractor are *system integrators* who has influence over innovation during the design stage, whilst the principal contractor has influence over innovations during the construction stage. Accordingly, Falu municipality has taken control over these system integrators and thereby gained influence over innovations.

5.4.4.6 Summary of lessons learned in Falun

The municipality has implemented a timber strategy in 2011, BIM and ICE in 2013 and new public procurement procedures and Construction Management in 2014. BIM and ICE enable the municipality to take control and improve the design phase of the building process. The result is a shorter design phase due to instant problem solving. It also enable industrial building methods and different procurement methods due to higher technical standard in the projects. The use of BIM also increase the local competence resources regarding timber building, which can be an incentive for small municipalities to network with Falun and use these competencies. From an MLP perspective, technical lessons learned develop the timber niche innovation further.

Falun also implemented divided procurement methods. This favor local SME and increases the client control of the building process. From an MLP perspective, an increased influence over building processes enable better articulation of the client needs and expectations. Taking up to role as a main contractor demands a more active and cunning client. Implementation of BIM and ICE and divided public procurement resulted in some organizational changes, for example increased coordination in building projects was required. Construction Management has been initiated as a result of the increased responsibilities at the public clients.

The municipality also participate in a three year public procurement project called Innobuild. This project include identifying needs and state-of-the-art solutions. Public procurement is then specified with functional needs rather than price. Sustainability and innovation are prioritized areas, and learnings from this project have been applied on other parts of the operations in the municipality.

5.4.5 Niche momentum in Falun

This segment aims to describe niche developments have come in terms of momentum. Momentum can be considered as the strength of the niche, aiming at facilitating a deep structural transition where the socio-technical regime incorporate the niche innovation. The momentum depends on articulation of visions or expectations, commitments from growing networks and lessons learned. Momentum is gained if visions and expectations become more precise and broadly accepted, when lessons learned align in a “dominant design” i.e. stable configuration or when networks grow large and powerful actors commit to take up the novelty.

The municipality of Falun adopted a timber building strategy in 2011. This strategy made the visions and expectations regarding timber building more precise. Moreover, the public clients of Falun have taken an active role in the construction projects, working with various ways of articulation the expectations of the municipality. Timber building has been part of these expectations since industrial building is perceived as innovative, sustainable and energy efficient. Overall, the articulation of expectations is strong in Falun, particularly when considering public procurement practices. This has strengthened the momentum of the local timber building niche in Falun.

Local politicians have committed to timber building and other innovative approaches in Falun, strengthening the momentum. At the local scene, participation in formal networks increase the resource base of the timber niche, and a cluster of competence in Falun may encourage smaller municipalities to join the chosen approach in Falun. Getting bigger municipalities to adopt the ways of working in Falun would further increase the public procurers influence over the regime. Moreover, there is a possibility to involve other actors in the timber building niche, such as local industry (small house manufactures) when gaining influence over the building processes.

Lastly, momentum is gained when lessons learned align in a dominant design and stable configuration. The procurement and organizational processes in Falun is still under evaluation. With an increasing amount of demonstration projects a stable configuration will emerge. BIM and ICE can be considered as currently stable configurations in Falun. Regarding divided contracting methods and innovative functional public procurement, these new practices can be considered demonstration projects, but with increased documentation and stable routines, stable configurations probably will emerge here as well.

In summary, the public clients in Falun are challenging the current regime by gaining influence over the building processes. The design phase is influenced through BIM and ICE and the construction phase through divided contracting and innovative public procurement projects. This shift control to the clients, which is necessary in order to develop the local SME:s and the timber building niche. These actions have resulted in an increased momentum in the local timber building niche, and a better positions for articulation visions and expectations.

5.4.5.1 Conclusion

The municipality of Falun form a local sub-regime challenging the tradition regime. Momentum have been built upon a timber building strategy and taking control over the construction processes through BIM, ICE, CM and divided work contracting. This has resulted in some deep structural changes within the policy element in Falun, encouraging the local industry and timber building technology.

6 Discussion

6.1 Stage 1 conclusions

The intent of using the socio-technical approach is to contribute to a more holistic understanding of change. The first objective was therefore to assess and reframe the literature about the Swedish construction sector from a multi-level perspective, focusing on timber based building. Research stage 1 use MLP theory to illustrate and assess the national construction domain. MLP theory used in stage 1 focus on the socio-technical regime and the socio-technical landscape. Based on the analysis conducted in research stage 1, I conclude the following:

- Onsite concrete building systems constitute a socio-technical regime with considerable lock-in and path dependencies.
- Lock-in characteristics of the regime are due to sunk investments across the supply chain, specific competence regarding the concrete and steel building system, differences in national legal frameworks, traditional culture and a few dominant industry actors.
- Thus, the concrete regime is still dominant and stable in its configuration, although less stable than two decades ago when timber building first was introduced.
- Landscape developments such as functional building codes (1994 legalization change), environmental demands, increasing housing need and alarming production costs put pressure on the regime. This has resulted in a window of opportunity where the timber niche can advance.
- Internal realignment within the regime involve cutting production costs through framework agreements or strategic partnering, or incremental change towards energy efficient building.
- Timber building systems still constitute a niche after two decades, with practices deviating from the existing regime.

6.2 Stage 2 conclusions

The overarching aim of this thesis has been to assess how timber based building can become more mainstream. Two objectives are connected to researching stage 2:

1) Assess and frame timber based building niches, their origin and developments
2) Assess the momentum of these niches, with regards to a transition towards mainstreaming timber based building.

Three extreme cases have been studied regarding the timber building developments and momentum. Primary and secondary sources have been used to obtain data, and the results have been illustrated and assessed using MLP theory. With regards to objective 1 and 2 above, the local timber building niche developments and momentum have been illustrated and assessed using the niche-development and momentum theory in MLP (see theory section 2.2.3.1). Accordingly, I conclude that the MLP framework is useful for illustrating and assessing local timber building developments in the chosen cases. Conclusions for each case is presented below.

6.2.1 Växjö municipality

With regards to objective number 2, the local timber niche momentum has been assessed based on niche developments presented in the results. Niche momentum refer to the strength of the niche in facilitating a deep structural transition within the socio-technical regime.

Regarding the municipality of Växjö, the timber building niche has built sufficient momentum for major structural changes in the local regime. Thus, a new local regime has grown out of the old regime, where timber building has become more mainstream and compete with existing onsite concrete methods. This transition pathway is further elaborated on in section 6.3.1.4. The current timber building momentum that made this transition possible is due to:

- A broad acceptance of Växjö's articulated expectations, including precise visions such as market share goals for timber building.
- Large social networks with commitments from local industry, local university and local politicians (triple helix).
- Lessons learned have aligned in a stable configuration due to a large amount of demonstration projects, active evaluation and learning.

6.2.2 The municipality of Skellefteå

The municipality of Skellefteå constitute a timber building niche, although the niche momentum is strong. The momentum in Skellefteå is due to:

- Adoption of timber building strategy in 2014.
- Commitment from local politicians, local actors (although active on a national arena) and research regarding timber building at the university (triple helix).
- Learnings from national networking and a few demonstration projects. The local niche has not acquired a stable configuration yet due to a lack of learning opportunities.

6.2.3 The municipality of Falun

The municipality of Falun has approached timber building with organizational changes and policy innovation. With regards to policy and organizational changes, Falun can be considered a local sub-regime, with major changes implemented regarding policy. However, regarding timber building techniques, the municipality still constitute a timber building niche since the local industry is yet to be developed. The local timber building niche momentum is due to:

- Timber building strategy in 2011, and strong articulation of functional needs in public procurement.
- Social networking in Dalarna and commitments from local politicians and nearby smaller municipalities. National networking contribute to the niche momentum as well.
- Lessons learned regarding organizational changes (BIM, CM, and ICE) and innovative public procurement (dividing work contracts and CM).

Moreover, some important lessons regarding controlling the construction processes have been made in Falun. As a public client, Falun has made local deep structural changes in the established contracting forms, taking over the role as a main contractor enabling articulation of visions and expectations, encouraging local SME and innovative building practices.

6.2.4 Overarching aim

The overall aim has been to assess how timber based building can become more mainstream. The three cases depicted show various ways of using local government and public actors in a transition towards increased timber building. The MLP framework has been useful for illustrating and assessing the gathered observations, and has proved useful for a more holistic understanding of how timber based building can become mainstream in the local cases. Accordingly, there are further measures that can be undertaken in the local cases in order to increase the timber building momentum. These are discussed in section 6.4.

6.3 Multi-level interactions and transition pathways

Figure 4 adopted from (Geels, 2012) illustrate how the three levels interact dynamically regarding socio-technical transitions. It highlights processes at different levels and its interactions. Arrows represent trajectories, or the path dependencies. Downward arrows also indicate that the landscape and regime influence the perceptions of the niche-innovation actors. Processes on multiple dimensions link up and enforce each other, so called circular causality. Therefore, there are no single drivers in MLP.

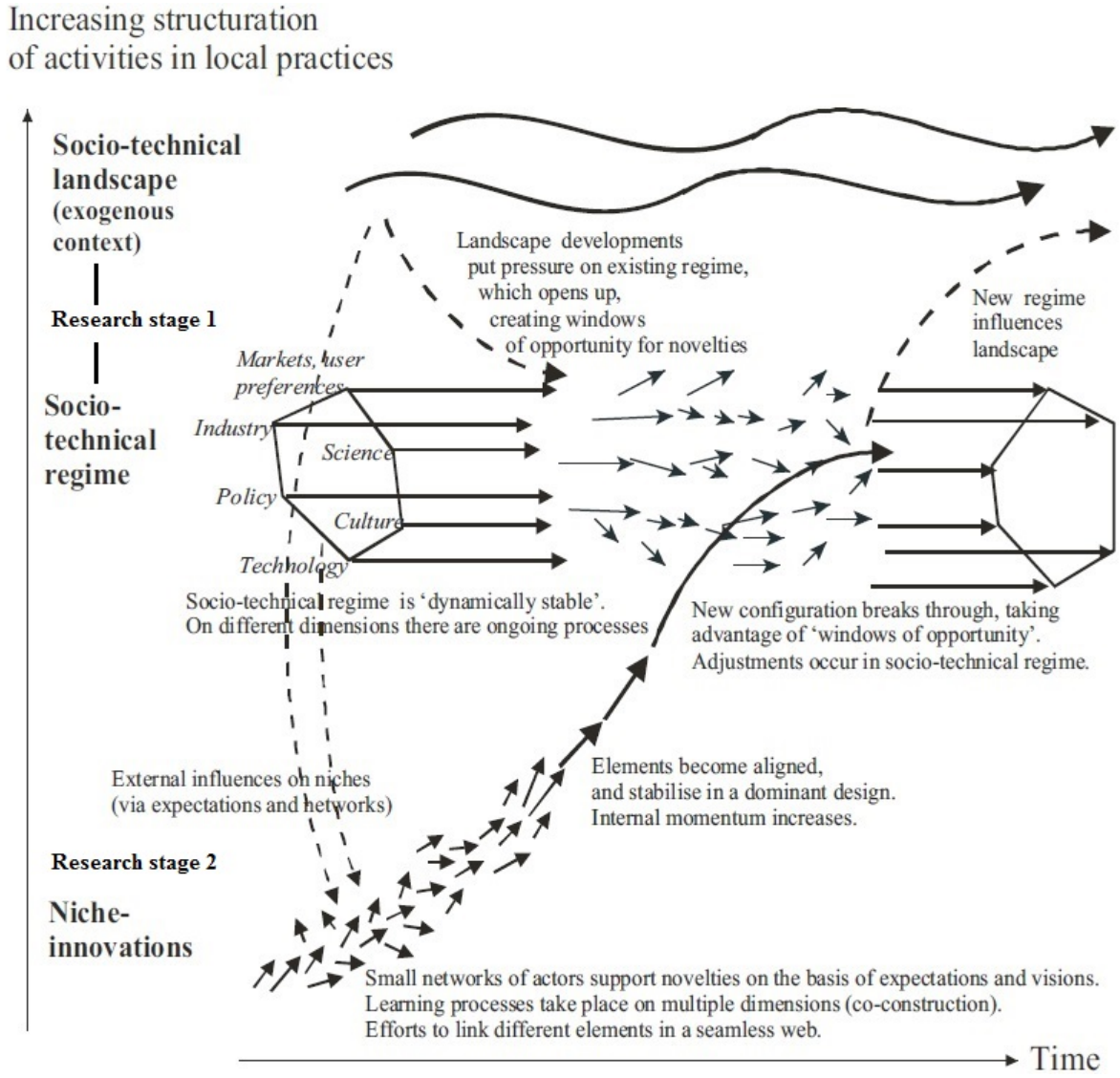


Figure 4. Transitions and interaction in MLP. Adopted from Geels (2012).

Stage 2 results illustrated and assessed the timber building niche developments and local momentum in three pioneering cases. Furthermore, Stage 1 research has illustrated and analyzed the socio-technical regime and socio-technical landscape. In summary, landscape pressures identified and assessed are: a) new functional building codes 1994, b) environmental demands c) vast housing needs and d) rapidly rising production costs. Moreover, the national onsite concrete regime is destabilized by rising production costs and environmental demands, although some realignment has occurred.

The internal momentum of the local timber niches have been concluded above under section 6.2. As showed in Figure 4, there are multi-level interactions involved in transitions from an old regime to a new regime. The next section elaborates on these interactions and transition pathways with regards to the *timing* and the *nature* of these multi-level interactions.

6.3.1 Transitions pathways

According to the theoretical frame of reference, radical transitions build upon the interaction of three hierarchical levels: 1) niches build up internal momentum 2) landscape developments put pressure on the regime 3) destabilization in the regime create windows of opportunities for niche innovations. MLP have been criticized for being biased towards bottom up change models, where radical innovations emerge in technological niches, enter market niches and successively diffuse into mainstream markets and replace existing regimes (Geels, 2011). This bottom up model can be elaborated into four possible transition pathways (see 2.3.2 for details). Below these pathways are discussed.

6.3.1.1 Transformation pathways

The transformation pathway occur when landscape changes exert pressure on the regime when niches are under-developed and cannot take advantage of the window of opportunity (when regimes are slow to adapt to landscape changes). The socio-technical regime instead realign its elements incrementally, thus no radically change occur. Niche-innovations may be added on into the regime, but in watered down form.

As shown in stage 1 analysis of landscape pressures, the national concrete regime has realigned due to post-production energy demands and rising building costs. National and local policy have aligned towards environmental concerns, prompting post production energy efficiency demands. Since conventional building techniques easily can be combined with energy-efficient techniques, minor changes in the regime occurred. Energy-efficient building techniques such as 'Passive house' techniques were adopted by the concrete regime, leading to basic architectural adjustments in regime policy, techniques, markets, user preferences etc.
This is known as the transformation pathway.

An example of add on to solve local problems with conventional building methods is adding on floors in existing concrete structures. Here timber building techniques have been adopted by the regime actors due to the lightness of the material.

Another example refer to the building code regulation change in 1994. When multi-storey timber building was allowed in Sweden, the niche was under developed and some regime actors took up timber building practices. At the local scene in Växjö for example, Skanska built Wälludden.

6.3.1.2 Technological substitution

Technological substitution may occur when niche innovations are well developed and landscape changes put pressures the regime. Cracks in the regime form a window of opportunity and niches with strong momentum break through and replace the existing regime technology. The regime then realign around this new technology. In this pathway, the relationship between niche and regime interactions is competitive. Thus, this pathway often lead to downfall of incumbent firms, which is unlikely in the case of the Swedish construction sector

6.3.1.3 Reconfiguration

If niche innovations are well developed when landscape exert pressure on the regime, the reconfiguration pathway may occur instead of technical substitution. If the relationship of the niche-regime interactions is symbiotic, niche-innovations can be easily adopted as add-on to solve problems. If the relationship is of a competitive nature, the new suppliers compete with existing suppliers. According to the theory, a sequence of transitions pathways is likely if landscape pressures persist. It begins with a transformation pathway, leading to reconfiguration and possibly substitution or de-alignment (regime collapse) (Geels, 2011).

The study shows that timber building in Sweden is entering a reconfiguration transition pathway, although starting out as a transformation transition. The environmental pressures and rising constructions costs resulted in a transformation pathway in the beginning of 1995. However, timber building has continued to grow momentum, especially in the studied local cases. The relationship with the regime interactions has been competitive (due radically new processes and environmental advantages). Some traditional actors within the regime has committed to the timber building niche, such as clients Folkhem and Rikshem. Moreover, the landscape pressures has persisted, indicating that deep structural changes within the national regime will follow the reconfiguration pathway. Some major structural changes include increasing competition within the industry element, increased focus on timber building within the science element, and policy changes encouraging new innovative construction methods. Furthermore, market demand for timber building is on the rise.

The national timber building niche will probably continue to grow momentum, although it is hard to see a complete substitution or regime collapse. The most credibly scenario is the reconfiguration pathway with increasing momentum for timber building niches and continuous regime adaption.

Within the local cases, Växjö has accomplished to create a local sub regime for timber building. The transition pathways are outlines below.

6.3.1.4 The example of Växjö

Due to landscape pressures, Växjö municipality adopted environmental and sustainability policies from the 1970s and forward (Växjö Kommun, 2013b). These are typical regime realignments following the transformation pathway. In 1994 the timber building niche started to build momentum, and in 2005 visions were articulated in a local timber building strategy and social networking expanded to include local politicians. Continuing to grow niche momentum in Växjö, a new local sub-regime have formed competing with the existing regime actors, following the reconfiguration pathway. Major and deep structural changes has occurred in the socio-technical system and its elements (technology, policy, industry, science, culture and markets). Old regime actors has survived and now compete with timber building actors, resulting in increased competition.

Momentum is critical in breaking through a regime and facilitating a transition. In the studied cases, public actors has encouraged timber building momentum in various ways. Following the theoretical framework, some recommendations are stated below in order to increase timber building momentum further in each local case.

6.4 Recommendations for increasing momentum in the local cases

The theoretical framework emphasize that niche momentum grows when visions and expectations become more precise, when lessons learned align in dominant design and when

social networks become large and powerful actors commit to the innovation. Based on the learnings from the application of the theoretical framework on the studied cases, the following recommendations are suggested:

- The municipality of Växjö is recommended to:
  - Continue articulate visions and expectations For example the innovations similar to the Falun case can be made regarding public procurement practices.
  - Aim to involve more and powerful actors, such as Södra or conventional concrete actors in timber building networks.
  - Evaluate methods for gaining influence over building processes as a public client.

- The municipality of Skellefteå is recommended to:
  - Aim for articulation of timber building market share goals.
  - Articulate and implement timber building strategies in all of its public companies.
  - Involve more actors in timber building networks, including local industry actors.
  - Procure more timber buildings and aim for stable routines and valuable lessons.
  - Evaluate methods for gaining influence over building processes as a public client.

- The municipality of Falun is recommended to:
  - Aim for the articulation of timber building market share goals.
  - Involve more actors in its network, including local industry actors.
  - Promote Falun's innovative measures through its networks.
  - Continue with incentives to develop local SME.
  - Evaluate and document its innovative measures with the aim of a stable configuration.

6.5 Recommendations for national and regional measures in facilitating a timber building transition

This thesis has shown that MLP can be useful when analyzing a transition towards timber building within the construction sector. Barriers, drivers and possible transition pathways have been discussed and assessed. All together, the studied cases indicate that the national timber building niche is increasing its momentum.

The result in the studied cases indicate that transition contribute to increased policy innovation, increased sustainability (lower GHG emissions), developments of local SME and increased competition in the construction sector. The analytical concept used for illustrating and assessing niche development in the pioneering cases can also be applied more generally in Sweden. Based on the experiences from the extreme cases, my assessment is that public measurements are powerful tools in the sustainable transition towards timber building. My recommendations for national and regional measures is therefore:

6.5.1 General measures for increase innovation in the construction sector

- Stimulate the emergence and momentum of niche innovations.
- Exert pressures on the regime through environmental legislation and economic instruments (CO2 taxes for example).
- Evaluate national building codes since this will decrease trade barriers and increase the demand for industrialized building.

6.5.2 Recommendations to grow national or regional timber niche momentum

- Articulate visions and expectations in order to attract interest for important actors and guide innovation activities. Momentum increases when visions and expectations become more precise and a broadly accepted. Example of articulation of visions in the studied cases are: local timber building strategies, market share goals, articulation of needs in public procurement.

- Continue building social networks with the ambition of enrolling more actors, especially powerful actors within policy, industry, market (clients), and science (Universities). This adds to the social and resource base of timber building. Niche momentum will grow if networks grow and powerful actors participate. For example, the enrollment of policy actors in national timber building strategy 2004-2008 increased the momentum of the timber building niche.

- Encourage learning on multiple dimensions such as technology, organizational, market demand, user behavior, policy instruments and infrastructure requirements. Momentum grow when lessons learned align in stable configurations and a dominant design. Also, keep an open mind in education regarding new building systems.

- Examples of local lessons learned are market demand (increased competition, lowering building costs) technology improvements (acoustics, stability, fire resistance, industrial building), organizational changes (Falun BIM, ICE, CM, divided work contracts), market demand (low cost, light weight, sustainable, energy efficient), infrastructure (investment in industrial building factories by industry actors) and policy (public procurement can increase innovation, local SME developments).

7 Method discussion

7.1 Theoretical framework discussion

Transitions are long term and complex phenomena, and the MLP have been criticized in ways of being difficult to apply empirically, since the scope of the regimes are hard to specify (Walker & Shove, 2007). The problem has been addressed in this thesis by defining the objects of analysis first, which primarily have been the local timber building niche developments. Then the regime have been specified with this in mind, and thereby the theory has been operationalized. Some studies focus solely on niches, but in this case it was judged that a literature study of the national regime would enhance the authors understanding of the phenomena. Also, assessing the national regime and the local niches makes use of the complete theoretical framework and allows for discussions about multi-level interactions.

The MLP have also been criticized for being overly simplistic and homogenous regarding the socio-technical regime, especially when studying niche-innovation and their struggle against regimes (Smith, Stirling, & Berkhout, 2005). This problem is addressed in the definition of a regime, where it is seen as semi-coherent rules guiding actor's perceptions and actions. As depicted in Figure 2, section 2.2.4 there can be tensions within a socio-regime. Each of the elements has its own dynamics, which contradicts the picture of a homogenous block. On one hand it has similar rules and homogeneity, and on the other hand differences in specific issues and internal conflict (Geels, 2011).

If conceptualized like this, the strength, homogenization and internal alignment in a socio-technical regime is an empirical question rather than an assumption (ibid). This is also a reason for the literature study conducted in research stage 1, where the internal dynamics of the regime as well as landscape pressures are considered.

7.2 Methodical discussion

7.2.1 Case and literature study

Frameworks such as the MLP draw on evolutionary economic science and technology studies, and can be considered a heuristic framework that guide the authors attention to relevant questions and problems (Geels, 2011). This require substantial knowledge of the empirical domain (ibid). Thus multiple methods is motivated in this thesis, starting out with a literature study and ending with a multiple case study of timber building niches.

Common critique towards the case study methods refer to generalization. However, critical cases may still contribute with valuable scientific knowledge. Case studies contribute to closeness to the actual practices and that the power of a pure example often is underestimated in favor of generalization of the results (Flyvbjerg, 2006).

This thesis limits to Sweden in stage 1 and the local cases in stage 2. To generalize the result to another spatial dimension such as another country, is hard since the construction domain is still a national business with limited competition from foreign countries. Moreover policy varies between countries and therefore, the studies regime and niches in this theses is limited to the chosen spatial scope. The scope of the literature study in stage 1 is national, therefore the results can be regarded as general for the Swedish multi-storey construction domain.

The scope of the chosen cases is pioneering local cases, so called extreme cases, aiming to show how far these local timber niches have come in a transition towards timber building. It is

important to emphasize that local government is strong in Sweden, and that local conditions vary. Most of the municipalities in Sweden differ from the extreme cases studied in this thesis in the way public actors take action on developing local SME and sustainable innovations. Therefore the results cannot be generalized over all municipalities in Sweden. Rather than generalizing, this thesis aims to illustrate the frontier of the local timber building niche and framing it from an MLP perspective.

7.2.2 Quality of data

The data collection originate from secondary sources (literature, journals, institutional data, and web sources) and primary sources; semi-structured interviews with five respondents. For the secondary sources, an assessment of the significance of the source to the thesis have been made in each situation, with the aim of using peer-reviewed journal articles as a firsthand source. The secondary sources vary from books and published journal articles to governmental reports and web pages.

There is always a risk of reproducing incorrect interpretations of secondary data, or reproducing incorrect research. However, the standards regarding sources have been validated through peer-review of experienced scientists.

Regarding the interviews, they have been conducted on Swedish, then transcribed and translated to English. When translating results there is always a risk of misinterpreting or mistranslation. Some expressions in Swedish do not have corresponding English translations. Therefore the essence in a sentence, rather than the exact words, been reproduced. In order to improve the quality of the data all interviews were recorded. After the results had been translated and put into context, respondents were asked to reread and approve the interpretations. This increases the validity of the study, i.e concern about subjectivity and measuring what is desired to measure. Moreover, multiple sources known as triangulation have been used adding to the validity of the study.

7.2.3 Alternative approaches

In this thesis, a hypothetico-deductive method have been chosen. This means that the theoretical framework have been studied first, and then the application of this theory on the domain have been justified with a series of observations drawn from existing literature and interviews. The construction domain is a new knowledge area for the author, whereas the knowledge about the forestry sector and forest product domain is high. This knowledge about the forestry section, combined with the chosen hypo-deductive approach constitute a risk of confirmation bias.

When considering alternatives approaches, one should remember that confirmation bias also apply to inductive methods regarding the objectivity of observations. An inductive approach, where observation are collected first and theories then postulated was disregarded due to the vast domain and the complexity of transitions. Moreover, the researcher is novice in the construction domain as well as regarding researching experience, which contributed to the choice of starting with an existing theoretical framework.

Another approach is Poppers falsification theory of method, or deductivism. This method avoids confirmation bias with rigorous tests for the theories. Again, considering the researchers experience as novice, trying to falsify a theory is advanced research work and not the purpose of this thesis, since this work is more of an illustrative nature. Moreover, when taking an established concept and applying it to a new domain, it is in the researchers nature

use the theory in an attempt to explain observations. This draw upon critique toward the falsification methods, stating that elimination of theories is not norm in actual science.

Concluding that a hypo-deductive methodology is best suited for this task, alternative approaches than a multiple study can be considered. Case studies was deemed appropriate due to the context dependent phenomena (see motivation in section 3.4). Regarding data collection, other approaches than the chosen would have been hard. A more extensive literature study could have been conducted and the niche cases left out. Due to the limited literature regarding timber niches, this method was ruled out. On the other hand, only primary data could have been used. The broad and holistic nature of the studied domain would have made that hard as well.

7.2.4 Future research

This thesis show that a multi-level perspective (MLP) can be used to illustrate and analyze the Swedish construction domain, with specific empirical interest in timber building niches.

MLP is a comprehensive framework when analyzing transitions and it is hoped that further research use MLP to investigate the construction domain in Sweden and other countries. My analysis build upon multiple methods and direct and indirect data sources. An analysis that build on a wider empirical data, especially for the niches, could enhance the generalizability of MLP and contribute with new knowledge.

This analysis focus on extreme cases and the frontier of local timber building developments. Future research could explore the paradigm cases, i.e the regular municipal cases and the lock-in and regime tendencies that prevent these municipalities to build more environmental and cost-effective. A greater focus on the concrete regime in a wider spatial context, considering in depth the internal dynamics lock in, trajectories and regime cracks would enhance the understandings of the construction sector. Various sustainable niches and their relative momentum compared against each other would be an interesting addition to my research.

This thesis touches on the role of public procurement in facilitating a transition. The results indicate that public procurement can be used in facilitating transitions in the local cases. Växjö municipality has developed timber building far and deep structural changes in the regime has occurred. This should be studied in more detail. Moreover policy and organizational innovation in the Falun cases indicate interesting results. The role of public procurement in sustainable transition should be further researched and evaluated, especially within the Swedish context where public clients has significant influence on the construction sector.

Transitions is a vast and complex research area and MLP incorporate this in a comprehensive framework. MLP highlights the multi-dimensional development and co-evolution, but there are no large databases for statistical relationship between variables, since transitions are long-term and rare (Geels, 2011). Therefore, other theories and methodologies are encouraged, especially multi-dimensional and wide theories.

7.2.5 Concluding remarks

This thesis proposed to introduce a socio-technical approach into assessing the Swedish construction sector and its developments. The overall aim was to assess how timber based building can become more mainstream. The results show that MLP is a useful tool for reframing the construction sector with regards to timber building. It highlights barriers, drivers and pathways in a sustainable transition towards timber based building. Moreover the results

illustrate the current state of local timber building developments and their developments and momentum. It shows how public actors can increase competition and develop local SME within the construction sector, in a sustainable way. Multi-level interactions and transitions pathways are discussed, and recommended national and local measures are suggested for making timber building more mainstream.

MLP is comprehensive and useful framework, providing a holistic understanding of how deep structural changes can occur within a sector. It is the authors hope that MLP and socio-technical transitions are further studied and assessed.

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Distribution
Sveriges lantbruksuniversitet
Institutionen för skogens produkter
Department of Forest Products
Box 7008
SE-750 07 Uppsala, Sweden
Tfn. +46 (0) 18 67 10 00
Fax: +46 (0) 18 67 34 90
E-mail: sprod@slu.se